THE HIGH SPEED ELECTRONICS GROUP

Microwaves & RF

News
Previewing the 12th Wireless Symposium

Design Feature
Understand the benefits of ultranarrowband modulation

Product Technology
High-speed synthesizer spans 2.25 to 18 GHz

SiGe Fires Single-Chip Fractional-N Synthesizer

#BXNPGNX **********************AUTO**3-DIGIT 543
#533579017 5# RF 001 100 SCK 476
JOE LORITZ, ENGINEER
GBPPR
424 WILSON AVE
GREEN BAY WI 54303-4115

Wireless Show/ Communications Issue


performance

AMPLIFIERS FOR EVERY APPLICATION

Low Phase Noise Design and Test Capability new!

- Custom built to order
- Competitive pricing
- Delivery in 2 weeks ARO
- Military reliability

Broadband Power Amplifiers NEW

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ
JCA018-3000	2.0–18.0	25	6.0	2.0	23	28
JCA218-3001	2.0–18.0	25	6.0	2.0	25	30
JCA218-3002	2.0–18.0	25	6.0	2.0	27	32
JCA218-4000	2.0–18.0	30	6.0	2.0	23	28
JCA218-4001	2.0–18.0	30	6.0	2.0	25	30
JCA218-4002	2.0–18.0	30	6.0	2.0	27	32
JCA218-5000	2.0–18.0	35	6.0	2.0	23	28
JCA218-5001	2.0–18.0	35	6.0	2.0	25	30
JCA218-5002	2.0–18.0	35	6.0	2.0	27	32

Power Amplifiers

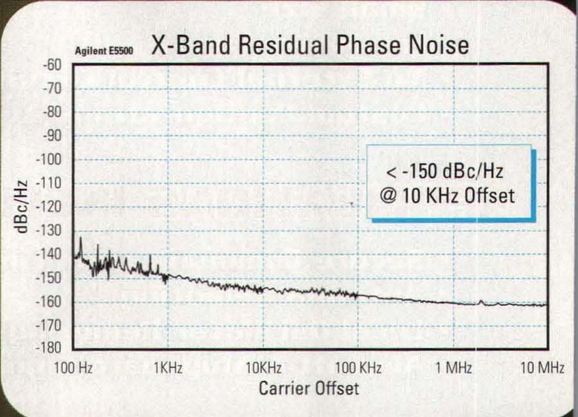
Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ
JCA12-P01	1.35–1.85	35	4.0	1.0	33	41
JCA34-P02	3.1–3.5	40	4.5	1.0	37	45
JCA56-P01	5.9–6.4	30	5.0	1.0	34	42
JCA812-P03	8.0–12.0	40	5.0	1.5	33	40
JCA1218-P02	12.0–18.0	22	4.0	2.0	25	35

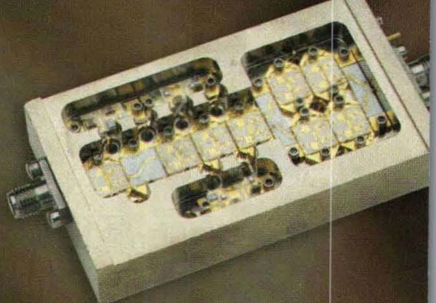
Low Noise Amplifiers

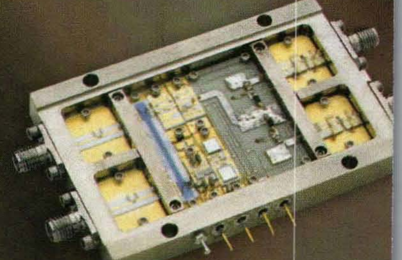
Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ
JCA12-1000	1.2–1.6	25	0.8	0.5	10	20
JCA12-3001	1.0–2.0	40	0.8	1.0	10	20
JCA23-302	2.2–2.3	30	0.8	0.5	10	20
JCA34-301	3.7–4.2	30	1.0	0.5	10	20
JCA78-300	7.25–7.75	27	1.2	0.5	13	23
JCA910-3000	9.0–9.5	25	1.3	0.5	13	23
JCA1112-3000	11.7–12.2	27	1.4	0.5	13	23
JCA1415-3001	14.4–15.4	35	1.6	1.0	14	24
JCA1819-3001	18.1–18.6	25	2.0	0.5	10	20
JCA2021-3001	20.2–21.2	25	2.5	0.5	10	20

Millimeter Wave Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ
JCA2629-201	26.0–29.0	19	5.0	1.5	5	15
JCA2629-401	26.0–29.0	35	5.0	1.5	5	15
JCA2730-205	27.5–30.0	15	5.0	1.0	15	25
JCA2730-302	27.5–30.0	26	5.0	1.0	8	18
JCA2730-502	27.5–30.0	43	5.0	1.0	8	18
JCA3031-102	30.0–31.0	18	5.0	1.5	8	18
JCA3031-302	30.0–31.0	34	5.0	1.5	8	18
JCA3031-405	30.0–31.0	40	5.0	1.5	15	25
JCA2640-301	26.5–40.0	30	5.0	2.5	0	10







Integrated Functions/Options

- Variable Gain Control
- TTL Switching
- Temperature Compensation
- Input/Output Isolators
- Waveguide Interface
- Detector Output
- Input Limiters
- Phase Matching
- Gain Matching
- Limiting Amplifiers
- Hermetic Packages
- Bias-T Output

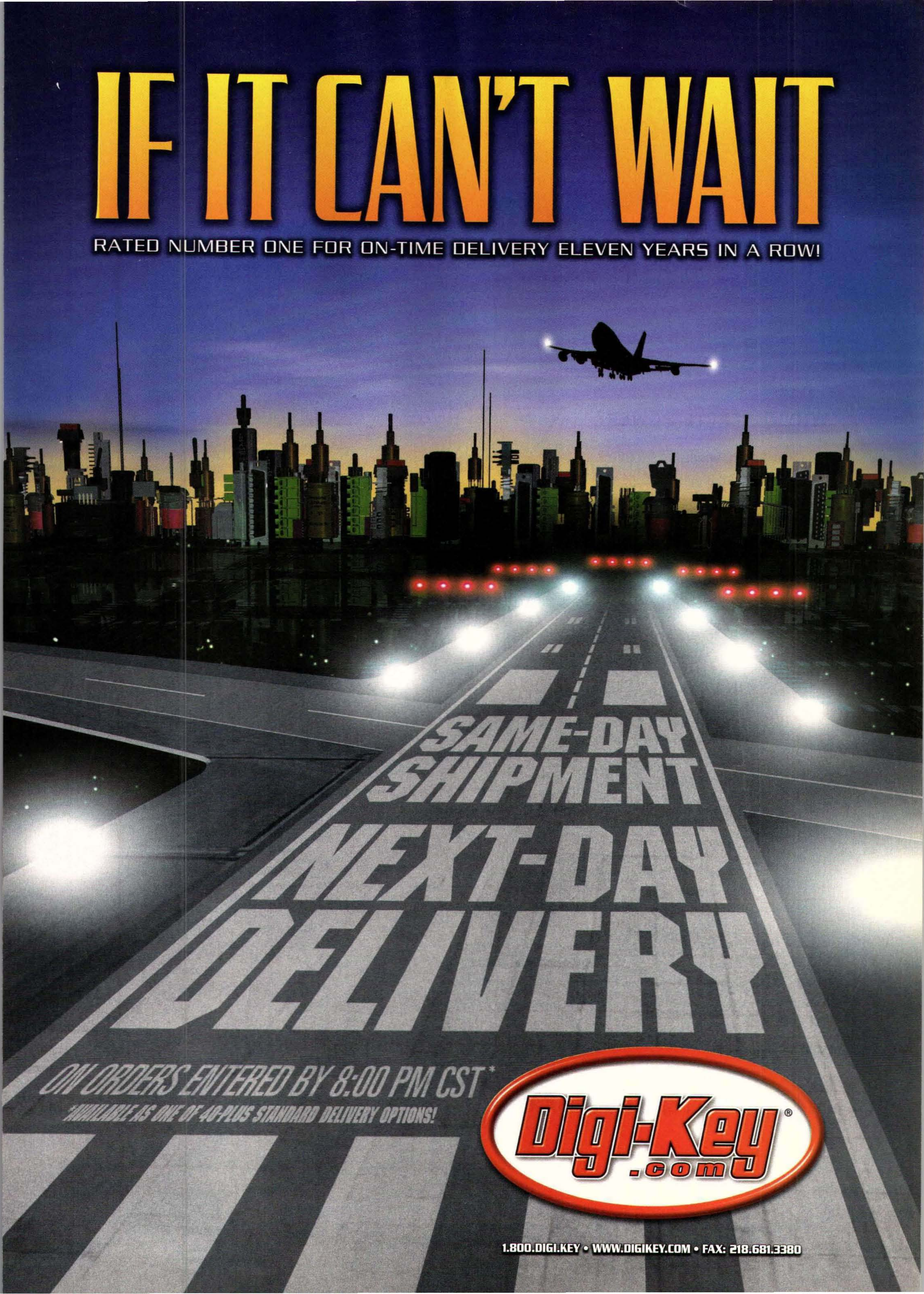
2584 Junction Avenue, San Jose, CA 95134-1902
p: 408 ▪ 919-5300 f: 408 ▪ 919-1505
www.jcatech.com ▪ e-mail: jca@jcatech.com

Request for quote! Call, fax, or e-mail.

Free catalog! Call or download.

JCA TECHNOLOGY

a NEW FOCUS® compar


IF IT CAN'T WAIT
RATED NUMBER ONE FOR ON-TIME DELIVERY ELEVEN YEARS IN A ROW!
SAME-DAY SHIPMENT
NEXT-DAY DELIVERY
ON ORDERS ENTERED BY 8:00 PM CST*
*AVAILABLE AS ONE OF 40-PLUS STANDARD DELIVERY OPTIONS!
Digi-Key.com
1.800.DIGI.KEY • WWW.DIGIKEY.COM • FAX: 218.681.3380

NO MATTER WHAT YOUR SHORT RANGE APPLICATION, WE HAVE A MEDIUM POWER TRANSISTOR TO DRIVE IT.

WHY DISCRETE POWER?

TWO WAY RADIO. WIRELESS SECURITY. METER READERS. If you're working on a 150 to 2500 MHz short range design, our medium power devices will get you to market faster and at a lower initial cost than a MMIC solution. Plus discretes offer several inherent benefits: Single power supply operation. Better heat dissipation. And higher efficiency — which can help prolong battery life in your fixed and portable designs. Best of all, with our broad product offering we probably have a device ideally suited to your specific application. Want data sheets? Visit us online now:

- Faster to Market
- Lower Price
- Greater Design Flexibility
- More Efficient
- Better Heat Dissipation

www.cel.com/srw.asp

PART NO.	FEATURES	P_{OUT}	DESCRIPTION
NE5520379A	3 W LDMOS	35 dBm @ 5 V	Applications to 1800 MHz
NE5520279A	1 W LDMOS	32 dBm @ 5 V	Applications to 2.48 GHz
NE552R479A	0.5 W LDMOS	27 dBm @ 5 V	Applications to 2.48 GHz
NE664M04	0.4 W Silicon	26 dBm @ 3.6 V	Driver or Medium Power Output
NE678M04	60 mW Silicon	18 dBm @ 2.8 V	Driver or Medium Power Output
NE677M04	30 mW Silicon	15 dBm @ 2.8 V	Driver or Medium Power Output

CEL California Eastern Laboratories

NEC
A Business Partner of NEC Compound Semiconductor Devices, Ltd.

NEC is a trademark of NEC Corporation.

California Eastern Laboratories ■ Santa Clara, California ■ 408 988-3500
DISTRIBUTORS: Arrow (800) 525-6666 Nu Horizons (888) 747-6846
Mouser Electronics (800) 346-6873

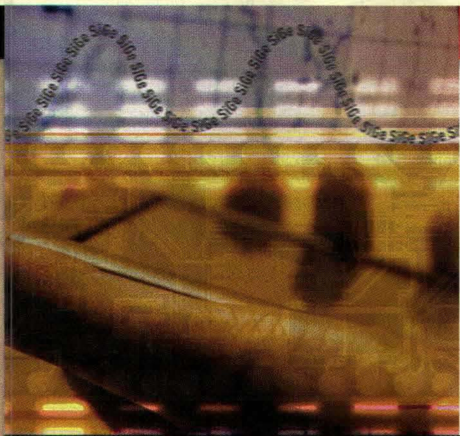
DECEMBER 2003• VOL. 42 • NO. 12

Microwaves & RF

A Penton Publication

Visit us at www.planetee.com

Departments



COVER STORY

News

Design

Product Technology

Design

Product Technology

Penton

BPA International

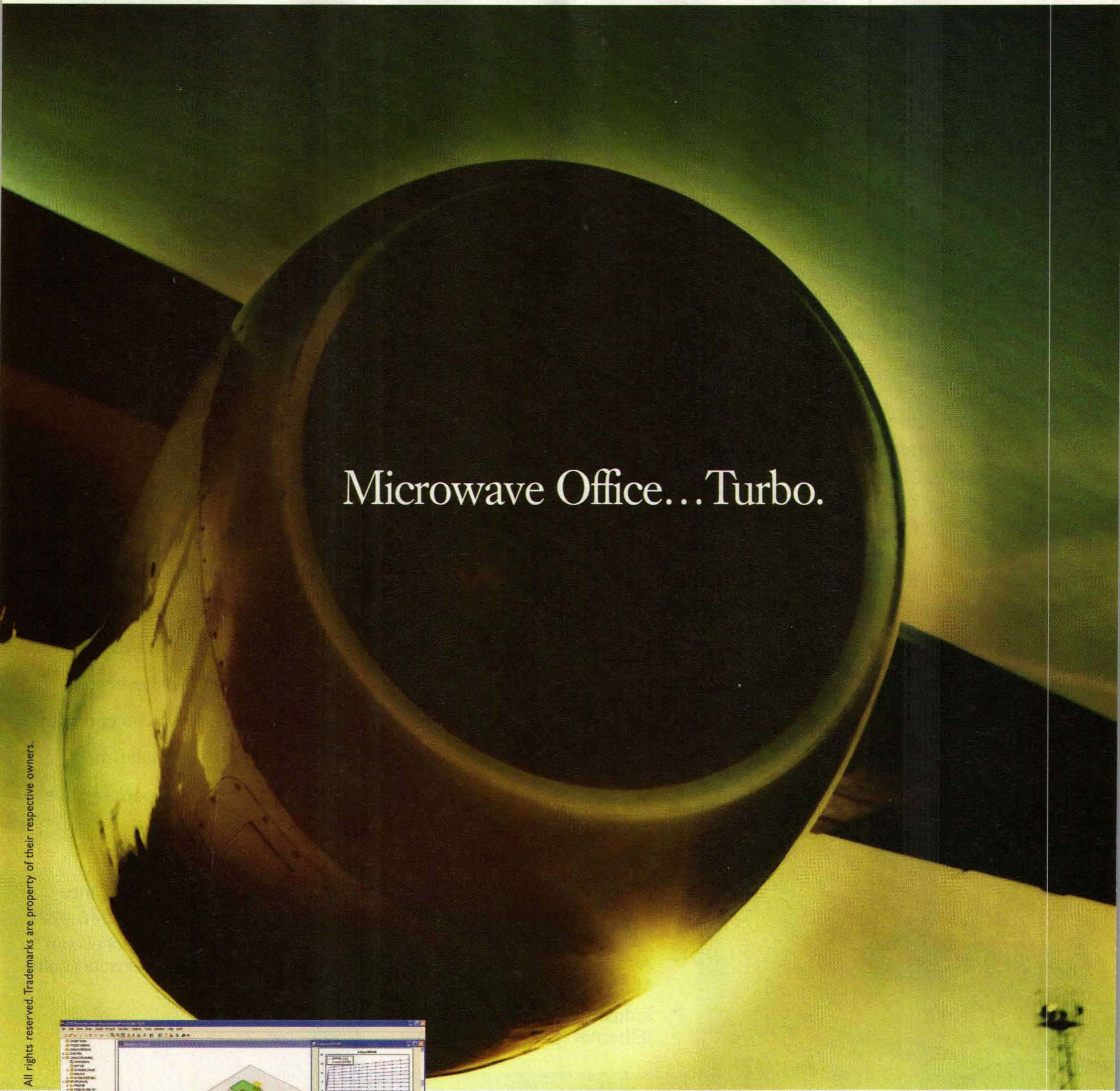
American Business Press

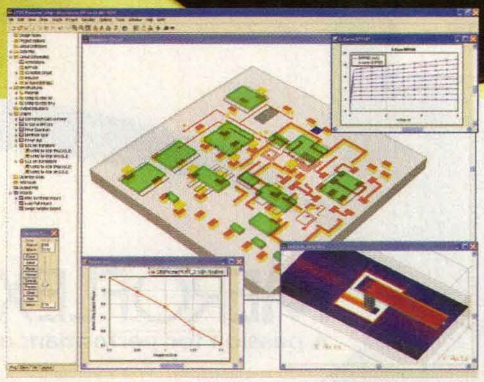
SUBSCRIPTION ASSISTANCE AND INFORMATION:

Microwaves & RF (ISSN 0745-2993) is published monthly, except semi-monthly in December. Subscription rates for US are $80 for 1 year ($105 in Canada, $140 for International). Published by Penton Media, Inc., The Penton Building, 1300 E. 9th St., Cleveland, OH 44114-1503. Periodicals Postage Paid at Cleveland, OH and at additional mailing offices.

Canada Post International Publications Mail (Canadian Distribution Sales Agreement #400268800). Canadian GST #R126431964. For paid subscription requests, please contact: Penton Media Inc., P.O. Box 2135, Skokie, IL 60076-7835. For all other Customer Service inquiries, contact: Penton Media Inc., P.O. Box 2095, Skokie, IL 60076-7995.

AWR

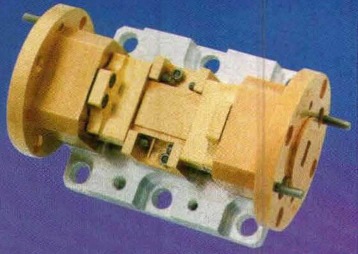




If you ever wondered about the horsepower of Microwave Office, it's time to overhaul your thinking. Because Microwave Office™ 2003 has a brand new engine —and more powerful performance than ever before. Now you can access both time domain and frequency domain simulation through the industry's most compelling interface. We've added the "gold standard" HSPICE® simulation engine from Synopsys® and turbocharged our new harmonic balance simulator to handle very large circuits—thousands of devices—faster than ever. We also incorporated arbitrary swept-variable analysis, new multi-layer substrate and transmission line capabilities, and an optional link to T&M equipment. Feel what it's like to fly through your designs. Download a 30-day eval from www.mwoffice.com or call us at 310-726-3000 for more details.

Microwave Office 2003

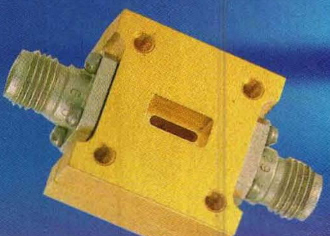
MILLIMETER WAVE
COMPONENTS
AMPLIFIERS • MIXERS • MULTIPLIERS



AMPLIFIERS

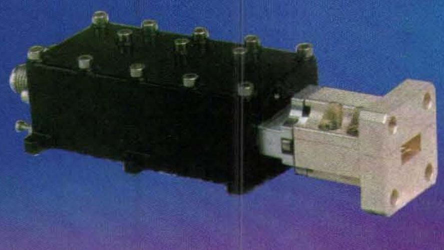
Model Number	Frequency (GHz)	Gain (dB, Min.)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	In/Out VSWR (Max.)	Output Power at 1dB Comp. (dBm, Typ.)
JSW4-18002600-20-5A	18-26	34	1.5	2.0	2.0:1/2.0:1	5
JSW4-26004000-28-5A	26-40	25	2.5	2.8	2.2:1/2.0:1	5
JSW4-18004000-35-5A	18-40	21	2.5	3.5	2.5:1/2.5:1	5
JSW4-30005000-45-5A	30-50	21	2.5	4.5	2.5:1/2.5:1	5
JSW4-40006000-55-0A	40-60	16	2.5	5.5	2.5:1/2.5:1	0

Higher output power options available



MIXER/CONVERTER PRODUCTS

Model Number	Frequency (GHz)			Conversion Gain/Loss (dB, Typ.)	Noise Figure (dB, Typ.)	Image Rejection (dB, Typ.)	LO-RF Isolation (dB, Typ.)
	RF	LO	IF				
LNB-1826-30	18-26	Internal	2-10	42	2.5	20	45
LNB-2640-40	26-40	Internal	2-16	42	3.5	20	45
ARE3436LC1	34-36	15.5-16.5	2.7-3.3	25	4	20	60
SBW3337LG2	33-37	33-37	DC-4	-7.5	8	N/A	25
TB0440LW1	4-40	4-42	.5-20	-10	10.5	N/A	20
DB0440LW1	4-40	4-40	DC-2	-9	9.5	N/A	25
SBE0440LW1	4-40	2-20	DC-1.5	-10	10.5	N/A	20



MULTIPLIERS

Model Number	Frequency (GHz)		Input Level (dBm, Min.)	Output Power (dBm, Min.)	Fundamental Feed Through Level (dBc, Min.)	DC current @+15VDC (mA, Nom.)
	Input	Output				
MAX2M260400	13-20	26-40	10	10	18	160
MAX2M200380	10-19	20-38	10	10	18	200
MAX2M300500	15-25	30-50	10	10	18	160
MAX4M400480	10-12	40-48	10	10	18	250
MAX3M300300	10	30	10	10	60	160
MAX2M360500	18-25	36-50	10	10	18	160
MAX2M200400	10-20	20-40	10	10	18	160
TD0040LA2	2-20	4-40	10	-3	30	N/A

Higher output power options available

MITEQ also offers custom designs to meet your specific requirements. For further information, please contact David Krautheimer at (631) 439-9413 or dkrautheimer@miteq.com

NQA
ISO 9001
REGISTERED COMPANY

MITEQ®

100 Davids Drive • Hauppauge, NY 11788
TEL.: (631) 436-7400 • FAX: (631) 436-7430
www.miteq.com

November Corrections

THERE ARE TWO corrections that need to be made for the November 2003 issue of *Microwaves & RF*.

The first concerns the Cover Story, "RF Design Environment Closes Verification Gap" (p. 86). Kal Kalbasi's name was omitted from the author's listing. Mr. Kalbasi should have been listed as a co-author of the piece, along with Jack Sifri and Mounir Adada.

The second correction is in the Infocenter section (p. 119). The e-mail address for Voltronics Corp. was listed incorrectly as info@voltronics.com. The correct e-mail address for Voltronics Corp. is info@voltronicscorp.com.

We apologize to Mr. Kalbasi, Voltronics Corp., and the readers of *Microwaves & RF* for any confusion that these errors may have caused.

The Editors of Microwaves & RF

MES Show 2003

MICROWAVE PHOTONIC Systems, Inc. exhibited for the first time at the 2003 Military Electronics Show, which was held in September at the Baltimore Convention Center in Baltimore, MD. While we had hoped for more traffic, the people who stopped by our booth made exhibiting at the show worthwhile. We have several deals in the works with large government agencies and corporations. We debuted our latest innovation, the MP-5000L, at the MES 2003 show, and it was very well received by the attendees.

The MP-5000L system is an ultrawideband, linear analog RF fiber-optic link designed to support a wide array of RF over fiber transport applications. The MP-500L is offered in three configurations:1.0 MHz to 3 GHz, 1.0 MHz to 6 GHz, and 1.0 MHz to 12 GHz. It can be used as the core of an optical Interfacility Link (IFL) subsystem designed to transport radio and satellite up and downlink signals between remote points separated by up to 20 kms.

In general, the show was a success for us. We will definitely consider exhibiting at the 2004 MES show.

Ed Woods
Microwave Photonic Systems, Inc.
West Chester, PA

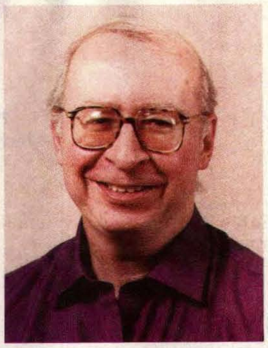
PLEASE COMMENT

Microwaves & RF welcomes mail from its readers. Letters must include the writer's name and address. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

Jack Browne
Publisher/Editor
Microwaves & RF
Penton Media, Inc.
45 Eisenhower Dr., 5th Floor
Paramus, NJ 07652
e-mail: jbrowne@penton.com

from the editor

Waiting For The Wireless Rebound



WIRELESS TECHNOLOGY came upon us in a flash during the 1990s. At first, it was the novelty of the cellular telephone, dialing a person rather than a place. Then the cellular telephone improved when it became "digital," and the rush was on to embrace this new way of staying connected. Concurrent with that growth came the acceptance of, and then dependence upon, the Internet during the last decade. And now wireless designers are faced with the challenge of combining these two former novelties into one reliable, mobile tool for home and office.

Many firms are banking on a "wireless resurrection" of sorts.

The perceived need for broadband networks motivated many telecommunications companies to push for the development of wideband wireless and high-speed optical technologies toward the tail end of the last decade, with the thinking that everyone would want fast Internet access in their homes and mobile Internet access all the time. Whether true or not, the commercial reality of transforming existing optical-communications infrastructures into 40-Gb/s networks and second-generation wireless networks into true broadband communications systems was brought into sharp focus by 1) limited bandwidths defined by cellular and PCS standards, 2) the prohibitive costs of the new technologies, and 3) questionable market demand.

As 2003 winds down, the RF/microwave industry finds itself facing yet another year of disappointing (for most) revenues and company financial spreadsheets. Some pockets of military electronics growth have sparked optimism for some companies. But the majority of firms that have depended on wireless markets for their livelihoods have found 2003 to be perhaps even more challenging than 2002.

Many firms are banking on a "wireless resurrection" of sorts, a return to strong demands for the hardware, software, and test equipment in support of wireless products. Perhaps some encouragement lies ahead in the Keynote Address for the 12th Annual Wireless Systems Design Conference & Expo planned by Dr. Henry Samueli, Co-Founder, Chairman, and Chief Technology Officer (CTO) of Broadcom Corp. (see p. 33). Dr. Samueli plans to review business trends that have affected the wireless marketplace so far, such as the early dependence on cellular sales. He also points to the growth of wireless as an "add on" technology for tomorrow's consumer electronics, in products such as gaming systems and home-entertainment centers, and the spread of wireless technology into industrial, medical, automotive, and other industrial segments.

Hope for growth in wireless markets depends on such diversity. By not depending upon a single aspect of wireless technology, such as cellular communications, the industry can hope for a more mature and balanced wireless marketplace in the future.

Jack Browne

Publisher/Editor

Microwaves & RF

A Penton Publication

HIGH-SPEED ELECTRONICS GROUP

Group Publisher Craig Roth, (201) 845-2448 • croth@penton.com
Publisher/Editor Jack Browne, (201) 845-2405 • jbrowne@penton.com
Technology Editor Nancy K. Friedrich, (201) 845-2428 • nfriedrich@penton.com
Managing Editor John Curley, (201) 845-2415 • jcurley@penton.com
Special Projects Editor Alan ("Pete") Conrad
Editorial Assistant Dawn Prior • dprior@penton.com
Contributing Editors Andrew Laundrie, Allen Podell

MANUFACTURING GROUP

Director Of Manufacturing Ilene Weiner
Group Production Director Mike McCabe
Customer Service Representative
Dorothy Sowa, (201) 845-2453, fax: (201) 845-2494
Production Coordinator Judy Osborn, (201) 845-2445
Digital Production Staff Louis Vacca, Pat Boselli
Color Manager Leilani Lockett

ART DEPARTMENT

Art Director Patrick Prince • pprince@penton.com
Group Design Manager Anthony Vitolo • tvitolo@penton.com
Senior Artist James M. Miller
Staff Artists Linda Gravell, Michael Descul

CIRCULATION CUSTOMER SERVICE (LIVE)

Phone: (847) 763-9670 • fax: (847) 763-9673
microwaves&rf@halldata.com

REPRINTS & PDFS

PentonReprints (888) 858-8851 • www.pentonreprints.com

EDITORIAL OFFICE

Penton Media, Inc., 45 Eisenhower Dr., Fifth floor, Paramus, NJ 07652
Phone: (201) 845-2446, fax: (201) 845-2493

PENTON TECHNOLOGY MEDIA

President David B. Nussbaum
VP, HR and Organizational Effectiveness Colleen Zelina

Penton
TECHNOLOGY MEDIA

Chairman & Chief Executive Officer Thomas L. Kemp
President & Chief Operating Officer/
President, Penton Industry & Retail Media Division Daniel J. Ramella
Exec. VP & President, Penton Technology & Lifestyle Media Division
David B. Nussbaum
Exec. VP & President, Penton IT & Lifetyle Media Groups Darrell C. Denny
Exec. VP & President, Penton Retail Media Group William C. Donohue
Chief Financial Officer & Corporate Secretary Preston L. Vice
Senior VP, Human Resources Katherine P. Torgerson
Chief Technology Officer & VP, Database Marketing Services
R. Thomas Jensen
VP, Corporate Communications Mary E. Abood

International editions are shipped via several entry points, including: Editeur Responsable (Belgique), Vuurgatstraat 92, 3090 Overijse, Belgique.
Microwaves & RF is sent free to individuals actively engaged in high-frequency electronics engineering. In addition, paid subscriptions are available. POSTMASTER: Send change of address to: Penton Media Inc., PO Box 2095, Skokie, IL 60076-7995. For paid subscription requests, please contact: Penton Media Inc., PO Box 2135, Skokie, IL 60076-7835. Publications Mail Agreement No: 40026880. Return Undeliverable Canadian Addresses to: Circulation Dept. or DPGM, 4960-2 Walker Road, Windsor, ON N9A 6J3. Canadian GST# R126431964.

Prices for non-qualified subscribers are:

	1 Yr.	Single Copies: Regular Issues	Single Copies: PDD Only
U.S.	$ 85.00	$10.00	$100.00
Canada	$110.00	$12.00	$125.00
Mexico	$145.00	$14.00	$125.00
All other countries	$145.00	$16.00	$125.00

Back issues of MicroWaves and *Microwaves & RF* are available on microfilm, microfiche, 16-mm, or 35-mm roll film. They can be ordered from Xerox University Microfilms, 300 North Zeeb Rd., Ann Arbor, MI 48106. For immediate information, call (313) 761–4700.

Synthesizer Solutions

New Series DS...

- FAST SWITCHING DIRECT SYNTHESIZER
- WIDE BANDWIDTH
- VERY LOW PHASE NOISE

The DS synthesizers are exceptionally quiet, fast, broadband and precise. Their phase noise rivals the best microwave fixed-frequency sources. With 300 nanoseconds typical switching time, the DS delivers ample speed to meet the required response times of most automatic test systems and frequency-agile equipment.

FEATURES

- Wide Bandwidth: 0.010 to 20.48 GHz Available in a Single Synthesizer
- Very Low Phase Noise: -120 dBc/Hz Typ. at 10 kHz Offset at 10 GHz
- 300 nanoseconds Typical Switching Time
- Steps Sizes Down to 1 Hz
- Low Profile Chassis or Compact Modular Configuration as small as 8"x 10"x 1.44"
- Standard Bands: 500 MHz to 18 GHz
  10 MHz to 10.24 GHz
  10 MHz to 20 .48 GHZ
- Custom Bands and Step Sizes
- Low Spurious
- Parallel BCD Programming
- Low Power Consumption/ High Reliability
- Low Sensitivity to Microphonics
- Locks to External Low Noise 100 MHz Reference

OPTIONS

- Addition of AM/PM/FM Modulation
- Computer touch screen front panel for rack mount unit
- Digital Frequency sweep

Frequency Range (MHz)	100 Hz	1 kHz (dBc/Hz)	10 kHz (dBc/Hz)	100 kHz (dBc/Hz)	1 MHz (dBc/Hz)
10 GHz	-92	-109	-120	-120	-128
1 GHz	-111	-127	-137	-139	-147
100 MHz	-125	-135	-145	-150	-153

GET THE PERFORMANCE YOU NEED for your Automated Test Systems, Radar, EW Simulation and Surveillance Equipment

CALL THE EXPERTS!

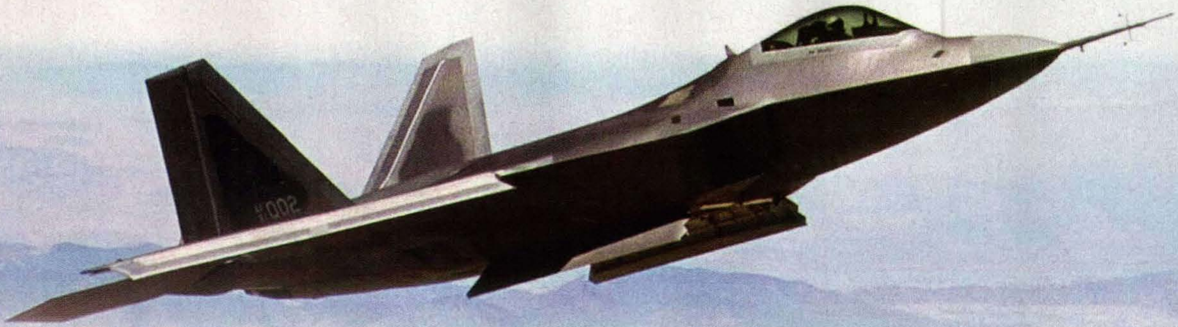
CTI COMMUNICATION TECHNIQUES
A DOVER COMPANY

9 Whippany Rd. • Whippany, NJ 07981
TEL: 973-884-2580 • FAX: 973-887-6245
www.cti-inc.com • e-mail: sales@cti-inc.com

ANSI-RAB QMS ACCREDITED BSI REGISTERED


VERSION / NINE
9
www.hfss.com
ANSOFT

HIGH PERFORMANCE
MIXER DESIGN



Cougar Components has designed a new line of frequency mixers to meet high performance applications. Available in hermetic packages using ruggedized lumped-element construction techniques, Cougar's frequency mixers are double-balanced designs using Schottky-barrier diodes, matching transformers for wideband performance.

Model	Frequency Range (MHz) RF	LO	IF	Lo Power Nominal (dBm) Typ.	Conv. Loss N.F. (dB) Typ.	IP3/IP2 (dBm) Typ.
MR3002	2500-3000	2500-3000	1-500	7	4.5	7
	2300-3500	2300-4000	DC-2000		5.5	7
MCH3008	5-1000	10-1500	1-500	10	6.0	20/50
	1-3000	1-3100	1-2000		7.0	20/50
	1-3400	1-3400	1-2000		8.0	20/50
MTS6031	10-3000	10-3000	5-1000	13	7.0	15/34
	3000-6000	3000-6000	5-1000		7.5	
	3000-6000	3000-6000	5-3000		8.0	
MS10623	7000-9000	7000-9000	DC-500	16	8.5	18/40
	6000-10000	6000-10000	DC-2000		9.0	18/40

Specifications are typical.

Signal Processing Components & Subsystems

COUGAR COMPONENTS

ISO 9001 & MIL-PRF-38534 Certified

290 Santa Ana Court, Sunnyvale, CA 94085
408-522-3838 • fax: 408-522-3839 • www.cougarcorp.com

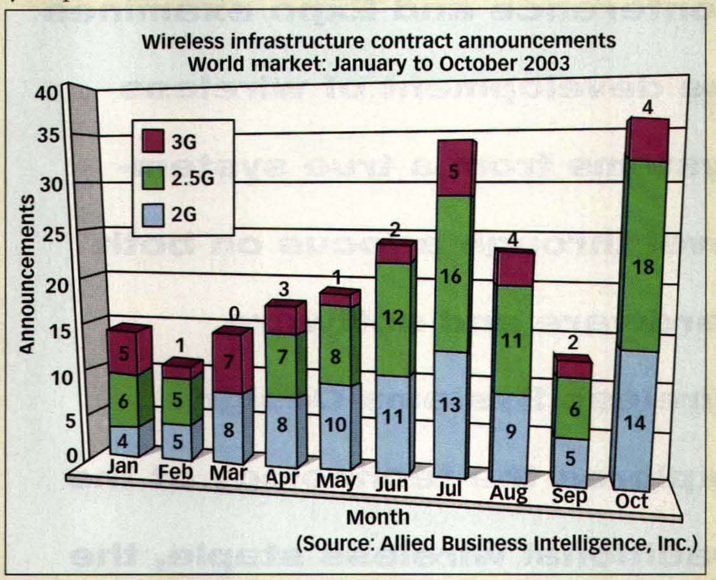
the front end

News items from the communications arena.

Demand For 3G Base Stations Outpaces Earlier Estimates

OYSTER BAY, NY—Technology market-research firm Allied Business Intelligence, Inc. (ABI) has revised their forecasts for wireless infrastructure. Demand for 3G, UMTS (universal mobile telecommunications system) base stations will actually outpace the earlier, conservative estimates that the firm issued **(see figure)**. Total UMTS deployments for 2003 will reach just about 35,000 units, versus earlier estimates of about 32,500.

Further analysis of contract wins shows that awards dipped in August and September of this year, but continued on the upward trend established earlier this year. Just over a third of all contracts were awarded in the Asia-Pacific region, with about one quarter awarded in the Americas. Europe captured slightly less than a quarter of the wins, with the Middle East and Africa taking 15 percent of all contract wins.



Though contract wins are on the rise, the overall market will not reach its previous highs any time soon. With the market peak exceeding $20 billion a few years ago, it is now well off those highs, with overall industry revenue set to reach about $17 billion in 2003. While the growth in the overall market will be hard to find, ABI projects UMTS equipment revenue growth of nearly 40 percent from 2003 to 2004.

Further details are available at www.abiresearch.com.

Aeroflex, Inc. Announces The Acquisition Of Celerity Systems

PLAINVIEW, NY—Aeroflex, Inc., a designer, developer, and manufacturer of automated testing solutions and microelectronics for the aerospace, defense, and broadband-communications markets, has announced the acquisition of the business of Celerity Systems, Inc. from L-3 Communications Corp. for $10.25 million consisting of cash, Aeroflex common shares, and a release of certain liabilities.

Celerity Systems designs, develops, and manufactures modular digital test and measurement solutions for the communications, satellite, wireless, and broadband test markets, including broadband signal generation.

"Earlier this year, we entered into a limited manufacturing and license agreement with Celerity," comments Len Borow, executive vice president and COO of Aeroflex. "As we have worked together with Celerity, it became obvious to us that their considerable intellectual property was an excellent fit with our IP, which, taken together, is expected to allow us to expand our product development in such areas as cellular base-station test systems. In addition, Celerity will continue to sell its products directly to government agencies and will also sell products to L-3 under an exclusive relationship for use in signal-intelligence and communications-intelligence systems. We expect Celerity to add six to seven million dollars in revenue and be accretive to earnings for our fiscal year ending June 30, 2004."

Aeroflex's common stock trades on the Nasdaq National Market System under the symbol ARXX.

"We are very excited about all of the activity around RFID."

China's Mobile-Phone Industry Experiences Explosive Growth

AUSTIN, TX—According to "Wireless And Mobile Communications In Beijing And China," a report from Communications Consulting Associates (CCA), 2003 is a pivotal time in setting the direction of China's immense mobile-telephony industry. Protection for the current two licensed mobile providers is being withdrawn, forcing already intense competition to cut-throat levels. At 250 million subscribers, China is the world's largest GSM network and the world's largest CDMA network. The leading fixed-line service providers are accelerating deployment of "fixed-wireless" PAS service, and competing indirectly with mobile service. Operator purchases from Chinese suppliers will exceed 40 percent in 2003, and continue to increase.

China Mobile and China Unicom floated bonds worth $18 billion to fuel a continuing massive network build out. By 2005, 70 percent of Beijing's population will be a mobile-service subscriber. As service providers continue the race for revenue growth and subscriber count, profitability appears to be wishful thinking.

Enhanced mobile-service capabilities are key to the government's push to "informationization" and e-government. Critical decisions on the choice of 3G technologies are overdue, and made more complex by global acceleration of competing technologies. Pressure is mounting to identify China's 3G standard and award more licenses.

Reliance on widespread 3G and WCDMA coverage is required for support of the 2008 Summer Olympic Games, which are scheduled to be held in Beijing. Network construction deadlines are fast approaching.

PowerPay RFID Solution Speeds Seahawks' Concession Sales

DALLAS, TX—According to a report from PR Newswire, exclusive Club Seat ticket holders at Seattle Seahawks NFL football games can now spend less time in the concession line and more time watching the game by paying for concession items with their Seattle Seahawks PowerPay™ token. The token features RF identification (RFID) technology from Texas Instruments RFid Systems (TI-RFid™). The PowerPay scheme was introduced during the 2003-2004 preseason, and 33 percent of the Club season-ticket holders have opted into the PowerPay program.

Developed by SMART System Technologies, Inc. of New York, NY, the PowerPay system allows Seattle Seahawks fans to pay for concession items on the Club Level by simply waving a Texas Instruments RF-enabled keyfob over a PowerPay reader at a point-of-sale terminal. Using the PowerPay Secure Marketing Architecture for Retail Transactions (SMART) network, payment information is transmitted wirelessly and securely, and the transaction is processed in seconds. PowerPay users do not have to worry about carrying cash to the game for concessions, and can have their purchases applied to the credit or check card of their choice. The Seahawks are supporting the program by providing opportunities for rewards and chances to win prizes for PowerPay users, including autographed Seahawks merchandise. PowerPay's SMART network allows merchants to create target groups of consumers and communicate relevant content and offers to individuals based on buying preferences and demographic data, then automatically reconcile those offers at the point of sale.

"The Seahawks are committed to giving their fans the best football experience possible, and the PowerPay solution enables them to reward fans with faster service and free merchandise while increasing revenues at the same time," comments Mark Johnson, president and CEO of SMART System Technologies, Inc. "With RF technology and PowerPay, we have created a total payment and CRM solution for the sports and retail industries that will benefit teams, venues, merchants, and consumers."

In 1997, Texas Instruments launched its RF technology for wireless payment with the introduction of the ExxonMobil Speedpass™, which boasts more than 6.5 million active users. In July 2003, TI also announced a new RF-based payment program with American Express, known as ExpressPay™, which has been deployed at more than 250 merchant locations in the Phoenix, AZ area. "We are very excited about all of the activity around RFID," says Johnson. "It has been accepted as a valid payment methodology, and we have taken it to the next level by utilizing RF technology as the gateway to our suite of products."

For further information on wireless payment applications from Texas Instruments RFid Systems, visit the company's website at www.ti-rfid.com. For more information on PowerPay, see their website at www.PowerPayIt.com.

Ceramic Resonator
Oscillators CHALLENGE
SAW Performance
PHASE NOISE
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
-150.0
-160.0
-170.0
100
1K
10 K
100K
1M
SAW @ 2488.32 MHz
CSO Series @ 2488.32 MHz
FEATURES:
• Low / Uniform Thermal Drift
• Small Size, Surface Mount
• Exceptional Phase Noise
+ 100°C
CSO SERIES
TEMPERATURE
SAW
- 40°C
New
SYNERGY
MICROWAVE CORPORATION
CSO Series
$AW
C$O
CSO SERIES
622.08
SAW
2488.32
FREQUENCY
For Additional Information,
Contact Synergy's Sales and Application Team.
201 McLean Boulevard, Paterson, NJ 07504
Phone: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Website: www.synergymwave.com
SYNERGY®
MICROWAVE CORPORATION

M/A-COM Is Awarded Radio Communications Contract

LOWELL, MA—A report from PR Newswire states that M/A-COM, Inc., a business unit of Tyco Electronics and a manufacturer of IP-based public-safety communication systems, was awarded a $15 million contract by the city of Milwaukee, WI to install its OpenSky network as the city's new communications system. The OpenSky system, coupled with NetworkFirst, M/A-COM's interoperability solution, will connect communications among all city and surrounding agencies, including police, fire, and public works. In addition, OpenSky's capabilities will allow these agencies to interoperate with other local, state, and federal agencies with operations in and around Milwaukee, further increasing their ability to respond to and manage emergencies.

"All of Milwaukee's agencies will be connected through the OpenSky IP network."

"Milwaukee was in need of a communications system that offered reliable and effective interoperable communications with other departments," says Chief Arthur Jones of the Milwaukee Police Department. "We are confident that M/A-COM's system is the most cutting-edge technology available, significantly increasing our ability to serve the citizens of greater Milwaukee."

The OpenSky system is a wireless private network based on Internet protocol (IP) that enables efficient voice and data communications between municipal and public-safety departments. All of Milwaukee's agencies will be connected through the OpenSky IP network, enabling different agencies to easily communicate. The Milwaukee Fire Department, for example, will be able to directly communicate with the Milwaukee Police Department and other city departments for the first time, improving collaboration among public-safety and municipal agencies.

"It was important for the city of Milwaukee to provide its public-safety agencies with what we consider the best communications technology available," comments David Adolf, district sales manager for M/A-COM.

Kudos

LONDON, ENGLAND—Spirent Communications has announced certification by the Global Certification Forum (GCF) of ten new test cases for the Spirent U-ATS UMTS Automatic Test System. This approval by the GCF certifies that Spirent's U-ATS system is capable of testing 3G WCDMA User Equipment (UE) to the requirements of the 3GPP TS 34.121 standard.

EWING, NJ—Discovery Semiconductors, Inc. is celebrating its 10th anniversary. The company began in 1993 as a "one-man, one-office" operation and has steadily grown into a global enterprise with exports to more than 17 countries.

ORLAND PARK, IL—Andrew Corp., a global communications systems equipment supplier, announced that it has received Registration to ISO 14001:1996 for its Nogales, Sonora, Mexico manufacturing facility. ISO 14001 is the international standard for environmental management systems. Activities carried out at the Andrew Nogales facility include the manufacturing of cable, pressurization, and antenna products for the telecommunications-infrastructure market.

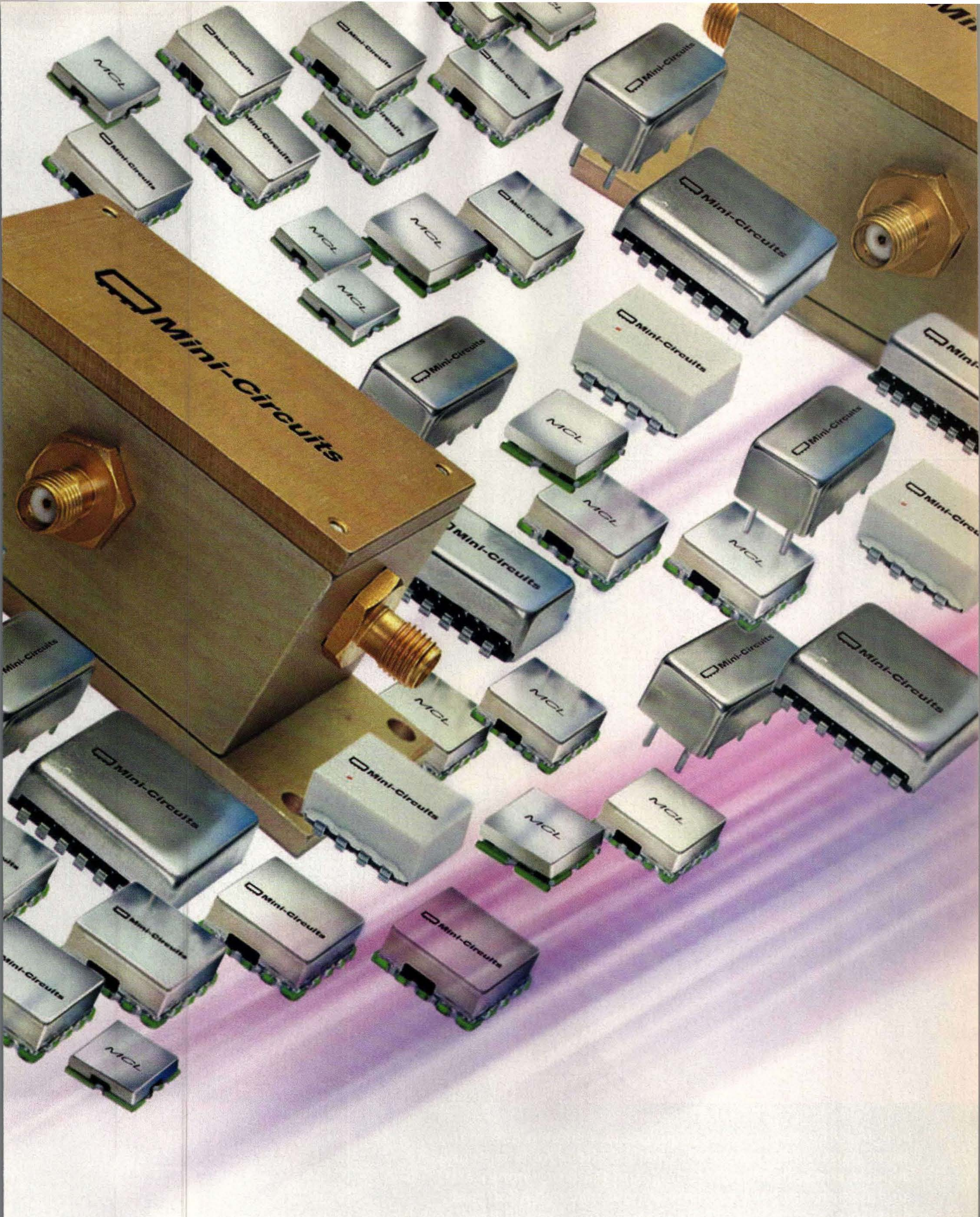
VISTA, CA—Palomar Technologies, a manufacturer of automated assembly systems, was featured on FOX 6 News San Diego on Tuesday, November 4. FOX 6 News, in conjunction with the University of California, San Diego (UCSD) CONNECT, broadcasts weekly news segments that provide the viewing audience with business-technology stories in the San Diego area.

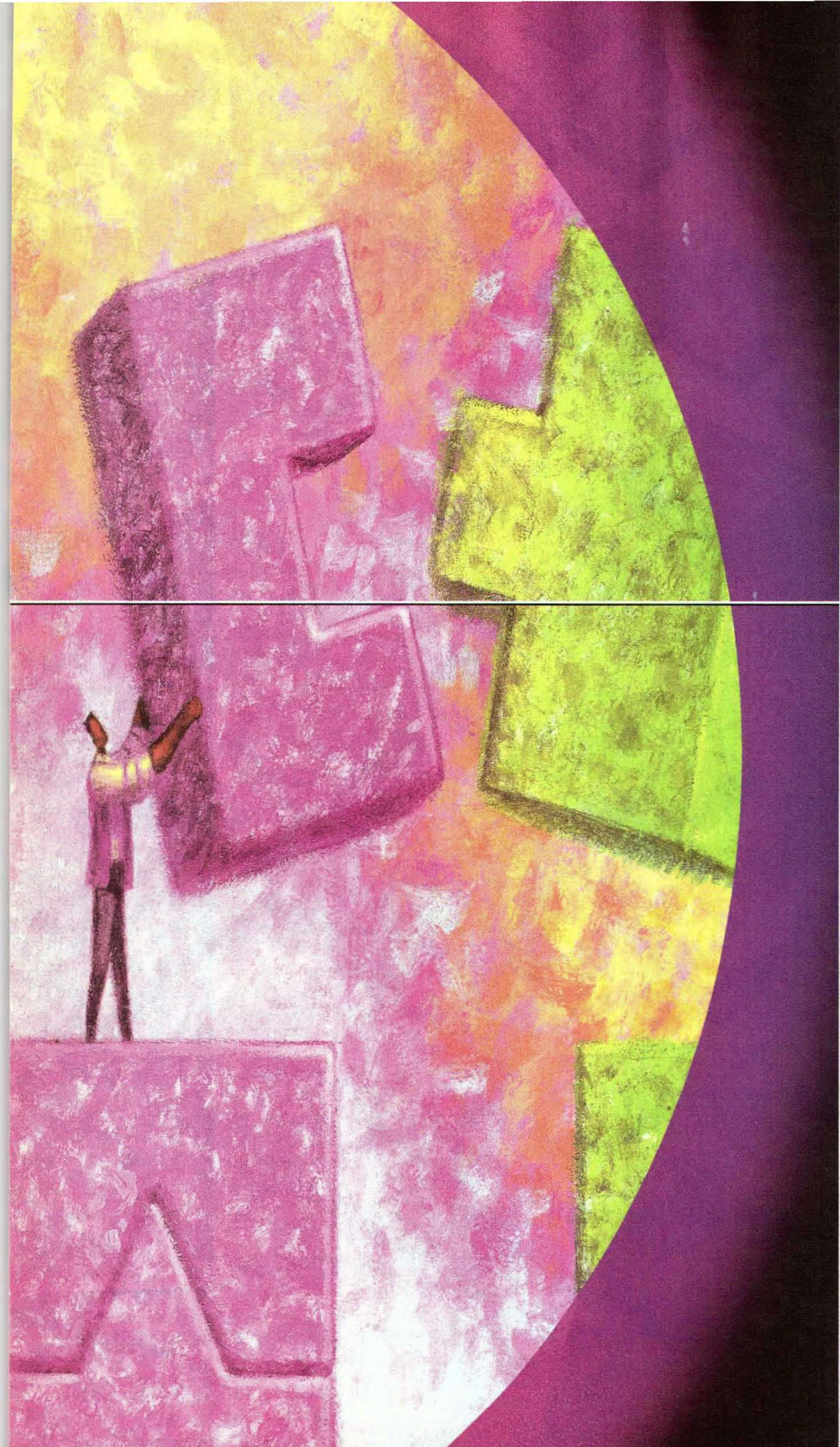
FOX 6 News' CONNECT segment explained Palomar's role in designing and manufacturing the precision automated equipment needed to assemble microscopic parts and components. Cameras peer through the microscope to capture gold wire "as fine as a spider web" that is electronically connecting the intelligence of each component to its circuit. A section shows how Palomar's machines are designed and modeled using sophisticated software.

Palomar's 2003 American Electronics Association (AeA) award, recent nomination for the UCSD CONNECT Most Innovative Product Award, and other awards and activities have generated interest in Palomar Technologies, leading to their FOX 6 News CONNECT spotlight.

WARREN, NJ—ANADIGICS, Inc., a supplier of wireless and broadband solutions, announced that its AWT6108 quad-band, GSM/GPRS module has been chosen as the recommended power amplifier (PA) by three major GSM reference designs. The selection of the AWT6108 PA in these reference designs is expected to increase the adoption of ANADIGICS' GSM/GPRS PA solutions in new handset models. MRF


Where Real Quality Counts
We Are There
Reliability
Performance
Integrity
MICROWAVE DYNAMICS
Phone: (714) 505-0998
Fax: (714) 505-0994
E-mail: info@microwave-dynamics.com
http://www.microwave-dynamics.com
Oscillators (DRO), Amplifiers
For Space, Military, & Commercial Use.
Over ten years of excellence
ISO 9001 : 2000
REGISTERED FIRM





NEWS

Wireless Symposium Moves To San Diego

The 12th Annual Wireless Systems Design Conference & Expo looks for a revival of wireless design activity in its new site in Southern California.

JACK BROWNE
Publisher/Editor

Wireless communications has become an integral part of the American lifestyle. Some parents wouldn't even dream of sending their children to school without their own cellular telephones. Wireless local-area networks (WLANs) represent one of the fastest-growing segments of the wireless market. In spite of a slowing in wireless infrastructure activity during the last several years, the overall wireless electronics market represents a considerable portion of total electronics expenditures, and design activity remains strong. And for design engineers faced with developing the next generation of wireless products, the Wireless Systems Design Conference & Expo 2004 remains the leading venue for sharing quality design and applications information on the latest wireless technologies. The event is scheduled for March 8-10, 2004 in the San Diego Convention Center (San Diego, CA). This first of three special reports previewing the 12th Annual Wireless Systems Design Conference & Expo will briefly review some of the technical sessions and keynote address.

Heading into its 12th year, the Wireless Systems Design Conference & Expo will enjoy a new base of operations in 2004, San Diego, CA. The conference and exhibition began life in Northern California (San Jose) and supported the strong base of design engineers centered around Santa Clara, Alameda, and San Mateo Counties for the last 11 years. During that time, however, Southern California (notably San Diego and surrounding areas) has enjoyed a period of rapid population growth, increased new-housing starts, and a steady increase in wireless design activity. While commercial companies such as QUALCOMM have remained visible through global activity in code-division-multiple-access (CDMA) networks and handsets, hundreds of smaller companies have contributed innovative twists to existing technologies and sometimes even total new technologies. In recognition of the growing wireless activity in San Diego, the Wireless Systems Design Conference & Expo was moved to the San Diego Convention Center for 2004 to provide a strong wireless design venue for local engineers (and those not-so-local wireless designers looking to escape frigid end-of-winter temperatures).

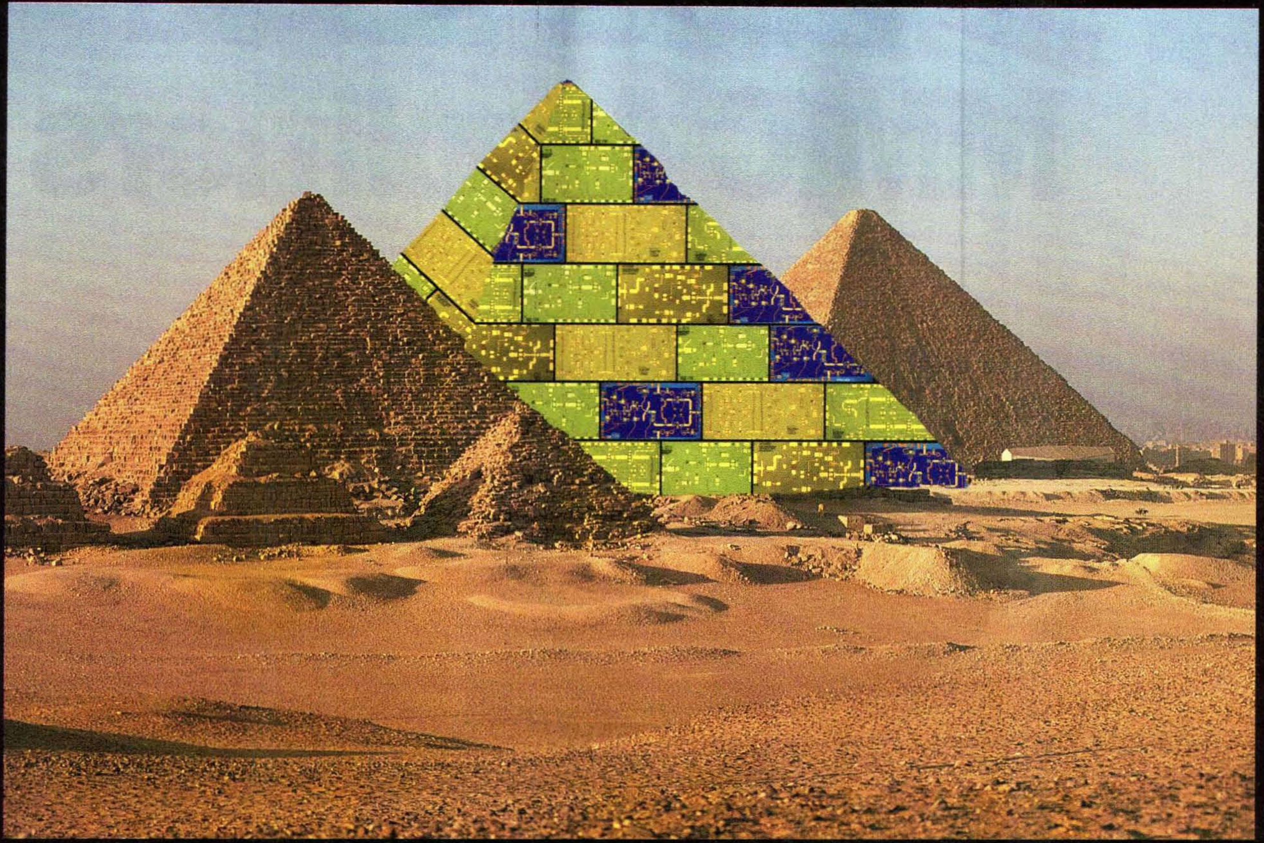
The opening day of the Wireless Systems Design Conference & Expo offers a Keynote Presentation from Dr. Henry Samueli, co-founder, chairman, and chief technical officer of

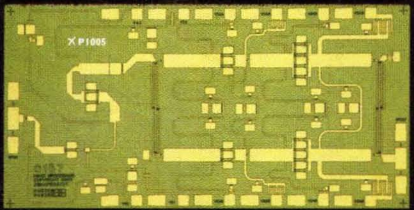
Broadcom Corp. (Irvine, CA). The company, with revenues of more than $1 billion in 2002 and third-quarter 2003 revenues of $425 million, is a leading supplier of silicon integrated circuits (ICs) and integrated solutions for wireless and wired networks. The company offers products for designers of cable modems, EDGE/GPRS/GSM handsets and networks, Synchronous Optical Network (SONET) OC-48 and OC-192 optical-communications ICs, transceivers, controllers, security chips, and application-specific integrated circuits (ASICs) for enterprise and small-office networks, and integrated solutions for personal-area networks (PANs), including chips for Bluetooth and WLAN systems. Dr.

> **Now in its 12th year, the WSD Conference & Expo is being held in San Diego, CA in 2004.**

Samueli, with more than 25 years experience in communications systems engineering and digital signal processing (DSP), has served as the company's CTO since its inception, and is responsible for all of Broadcom's research & development (R&D) activities. On leave of absence from the University of California at Los Angeles (UCLA) since 1995, he has been a professor of Electrical Engineering at that prestigious institution where he has supervised research programs on DSP and broadband communications circuits. Before establishing Broadcom in 1991, he was involved in a variety of development programs at TRW, Inc. (Redondo Beach, CA) on military satellites and digital radio communications systems.

Dr. Samueli's Keynote Address, scheduled for Monday, March 8, 2004 at 3:00 PM, is entitled "Wireless in Everything: Life in a Fully Connected World." He will address the perva-





XP1005

sive spread of wireless technology and how mobile and wireless technologies are setting the pace for many aspects of present-day and next-generation consumer electronics products. He will focus on several examples, including "unwired" home entertainment systems and public "hotspots" for wireless Internet access. He will also cover enterprise applications (data and paging networks), the evolution of game systems, portable telephones, and Personal Digital Assistants (PDAs), and explain how the inevitable, cost-effective solution lies in the design of an entire wireless transceiver on a single silicon CMOS chip.

The 12th Annual Wireless Systems Design Conference & Expo also features several panel sessions, including "Using Power Over Ethernet (PoE) to Empower the Proliferation of Wireless Devices" and a projection of future trends aptly titled "Where is the Wireless Industry Going?" The first panel session, moderated by Marco Thompson, Chairman of the San Diego Telecom Council, boasts an impressive lineup of technologists and marketing professionals, including Paul Greenland, Director of Product Marketing for the Power Management Group of National Semiconductor (Santa Clara, CA); Thong Huynh, Senior Corporation Applications Engineer for Maxim Integrated Products (Sunnyvale, CA), Steve Shalita, Senior Manager of Product Technology Marketing for Cisco Systems (San Jose, CA); Madhu Rayabhari, Marketing Director for Power Management Products at Fairchild Analog Products (South Portland, ME); David Dwelley, Design Manager for Power over Ethernet Products for Linear Technology Corp. (Milpitas, CA); and David Schie, Vice-President of Broadband and Telecom for Supertex (Sunnyvale,CA). The second panel session, which includes such esteemed panel members as Norm Korey, Vice-President and General Manager for Wireless E-Business, America, for IBM Global Services (White Plains, NY); Scott Smyser,

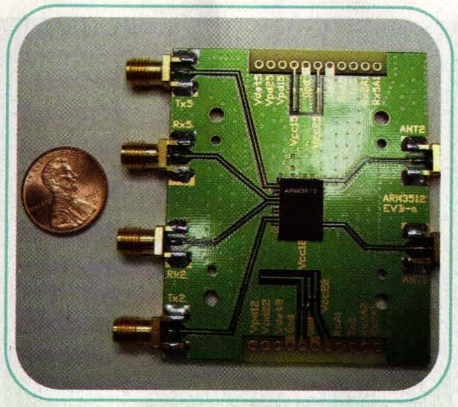
Senior Analyst for Frequency Control, RF, and Wireless for iSuppli (El Segundo, CA); and Robert Poor, CTO and Co-Founder of Ember Corp. (Boston, MA).

Next month's report will highlight the more than 60 technical presentations scheduled for the Wireless Systems Design Conference & Expo, including full sessions on broadband wireless networks, third-generation (3G) cellular technologies, handset design, design strategies for low-power applications such as radio-frequency identification (RFID) chips, power-management hardware and software, measurement techniques, wireless security issues and solutions, and WLAN design. For more information on the 12th Annual Wireless Systems Design Conference & Exposition, visit the website at www.wsdexpo.com. MRF

Module Supports Three WLAN Modes

THE ARM3512B dual-band, tri-mode front-end module is designed for IEEE 802.11a/b/g wireless-local-area-network (WLAN) applications in the 2.4-to-2.5-GHz and 4.9-to-6.0-GHz frequency bands. The module features efficient GaAs heterojunction-bipolar-transistor (HBT) amplifiers for both frequency bands, with better than 27 dB gain and 18 percent efficiency, two power-down control lines to optimize transmit power, lowpass transmit filters, bandpass receive filters, and input and output impedance matching circuitry. The module, which runs from a single power supply, requires only external bypass capacitors for operation. Typical supply current for the low band is 140 mA, while the high band typically consumes only 250 mA typical current.

Araftek, Inc., 40990 Encyclopedia Circle, Fremont, CA 94538; (510) 580-2500, FAX: (510) 580-2508, Internet: www.araftek.com.

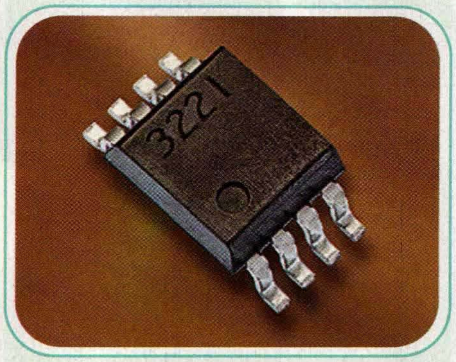


ARAFTEK'S ARM3512B FRONT-END MODULE

AGC Amp Boosts IF Signals To 100 MHz

DIFFERENTIAL INPUT/OUTPUT automatic-gain-control (AGC) amplifier model UPC3221GV is ideal for a variety of tuners and receivers requiring a wide level control range. The differential amplifier delivers 60 dB gain and an AGC range of 50 dB over a practical bandwidth of 10 to 100 MHz. The typical noise figure at 45 MHz and the maximum gain setting is 4.2 dB. The typical third-order intermodulation distortion with tones of 44 and 45 MHz at –30 dBm per tone is –47 dBc. The differential architecture simplifies integration with a surface-acoustic-wave (SAW) filter on the input and data converter on the output. The +5-VDC amplifier is supplied in an 8-pin SSOP housing.

California Eastern Laboratories, Inc., 4590 Patrick Henry Dr., Santa Clara, CA 95054; (408) 988-3500, FAX: (408) 988-0279, Internet: www.cel.com.

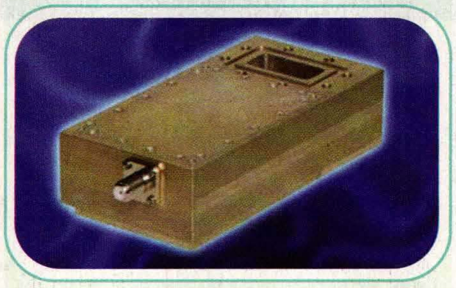


CEL'S AGC AMPLIFIER MODEL UPC3221GV

LNB Downconverts 7 GHz Satcom Band

MODEL LNB-6300-50-112VS-500 is a low-noise block downconverter (LNB) designed to downconvert X-band satellite signals from 7.25 to 77.75 GHz to an output frequency range of 950 to 1450 MHz. It operates with a local oscillator (LO) at 6.30 GHz and features phase noise of –95 dBc/Hz offset 100 kHz from the carrier with a typical noise figure of 1.3 dB. Nominal conversion gain is 50 dB while gain flatness is ±0.5 dB per 40-MHz band. The X-band LNB operates on supply voltage of +15 to +18 VDC and draws 500 mA maximum current. The module exhibits maximum input VSWR of 3.0:1 (for an impedance of 50 Ω) and a maximum output VSWR of 2.0:1. It is designed for operating temperatures from –30 to +60°C.

Tampa Microwave Lab, Inc., 12160 Race Track Rd., Tampa, FL 33626-3111; (813) 855-2251, FAX: (813) 855-7741, e-mail: sales@tampamicrowave.com, Internet: www.tampamicrowave.com.

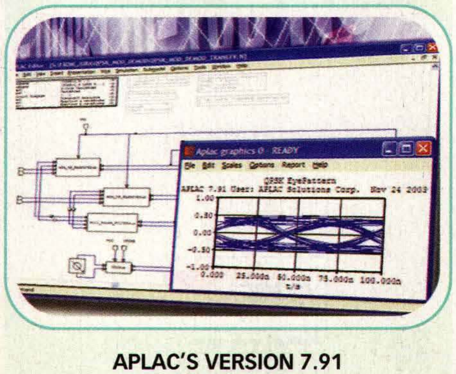


TAMPA MICROWAVE'S MODEL LNB-6300-50-112VS-500 LNB

RF Simulator Receives Upgrade

VERSION 7.91 OF APLAC, the versatile personal-computer (PC)-based RF circuit design and analysis software, introduces a new interface for interoperability with Matlab mathematical modeling software. The new version executes Matlab commands on simulation data, allowing APLAC analysis operations to be completed in a fraction of the time of earlier software versions. The software also includes a new WLAN signal generator block and an IMT2 mixer model. Version 7.91 also includes several new models for integrated-circuit (IC) and system-level design.

APLAC Solutions Corp., Lars Sonckin kaari 16, FIN - 02600, Espoo, Finland; 358 (0) 9 540 450 00, FAX: 358 (0) 9 540 450 40, e-mail: sales@aplac.com, Internet: www.aplac.com.



APLAC'S VERSION 7.91 RF SIMULATOR

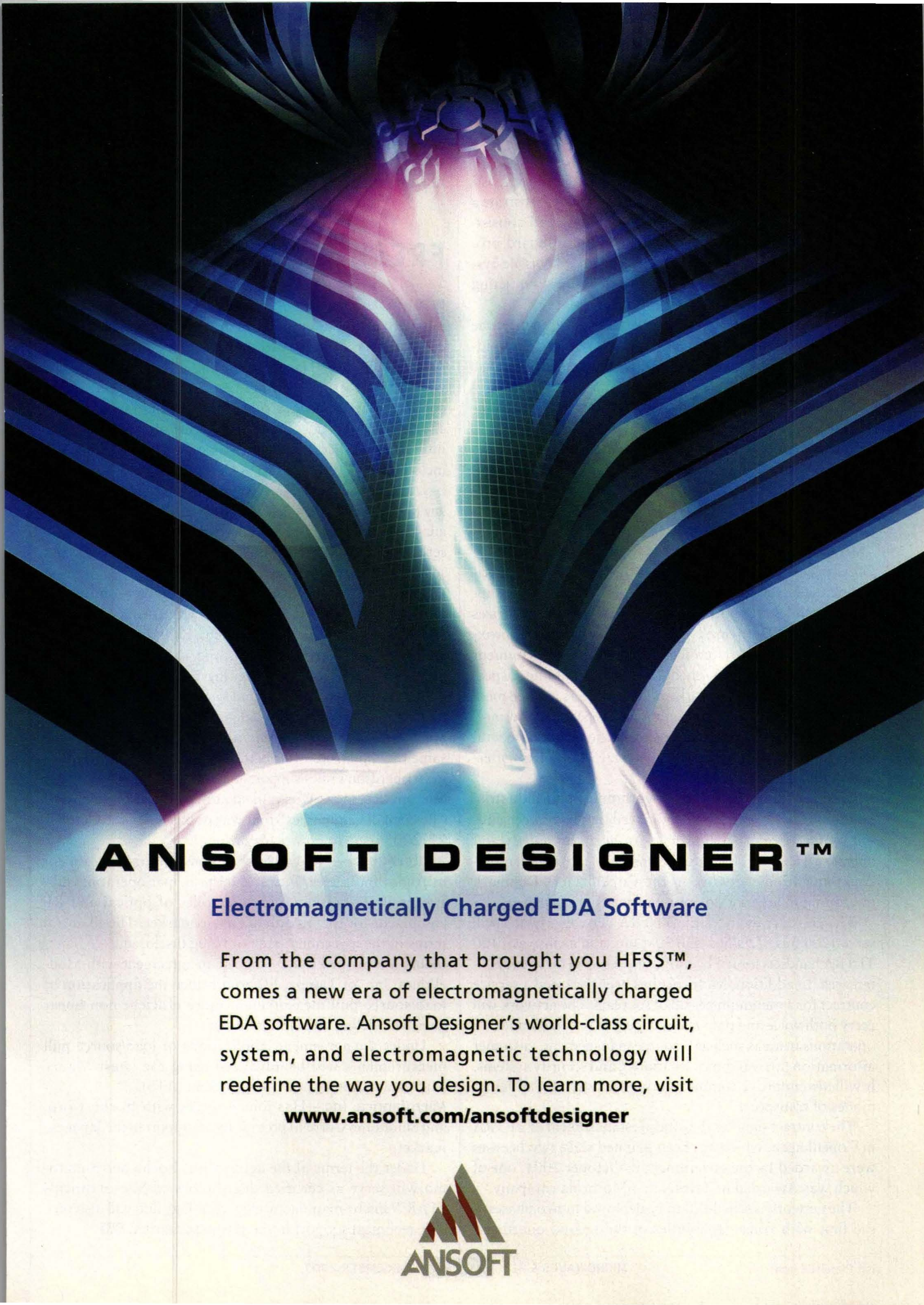
QUALCOMM Announces Q4 Results

QUALCOMM, INC. has announced its fourth quarter and fiscal 2003 results ended September 28, 2003. Revenues were $909 million in the fourth fiscal quarter, up 4 percent year-over-year. Fourth-quarter net income was $291 million and earnings per share were $0.35, up 53 percent and 52 percent year-over-year, respectively. Revenues were $4.0 billion in fiscal 2003, up 31 percent compared to fiscal 2002. Fiscal 2003 earnings were $827 million and earnings per share were $1.01, both up 130 percent compared to fiscal 2002.

Revenues excluding the QUALCOMM Strategic Initiatives (QSI) segment were $870 million in the fourth fiscal quarter, up 4 percent year-over-year. Fourth-quarter net income excluding the QSI segment was $236 million and earnings per share were $0.29, down 5 percent and 6 percent year-over-year, respectively. In fiscal 2003, revenues excluding the QSI segment were $3.8 billion, up 32 percent compared to fiscal 2002. Fiscal 2003 net income excluding the QSI segment was $1.2 billion and earnings per share were $1.42, up 46 percent and 45 percent, respectively, compared to fiscal 2002.

"The employees of QUALCOMM have delivered an outstanding year of exceptional performance both in financial results and in advancing wireless services and their usefulness to consumers and businesses around the world," says Dr. Irwin Mark Jacobs, chairman and CEO of QUALCOMM. "Among the many accomplishments was the shipment of our billionth chip, demonstrating our continued leadership position in the development and on-time delivery of CDMA chip sets.

"In 2004, we look forward to the world continuing its migration to the most economic wireless platform, CDMA," continues Jacobs. "As additional operators launch CDMA2000 1X, 1xEV-DO, and WCDMA, there will be an ever-increasing need for multimode multiband handsets to enable true global roaming. In response to market demands, we plan to significantly increase our R&D spending and build on our innovations delivering the most cost-effective and integrated CDMA-based products." MRF


ANSOFT DESIGNER™
Electromagnetically Charged EDA Software
From the company that brought you HFSS™, comes a new era of electromagnetically charged EDA software. Ansoft Designer's world-class circuit, system, and electromagnetic technology will redefine the way you design. To learn more, visit
www.ansoft.com/ansoftdesigner
ANSOFT

CONTRACTS

Raytheon Co.—Has been awarded a $37.4 million cost-plus-fixed-fee contract to define, design, and demonstrate a Space-Based Radar (SBR) pre-prototype payload consisting of an electronic scanned array and an on-board processing component. The Air Force's Space and Missile Systems Center, Los Angeles Air Force Base, is the contracting agency.

The developmental payload will be designed to meet the tactical/national user near real-time data needs for ground-moving-target indication (GMTI), synthetic-aperture radar (SAR), and digital terrain-elevation data.

Contract work is scheduled to be complete by September 2004.

TESSCO Technologies—Was awarded the General Services Administration (GSA) Test and Measurement Equipment contract No. GS-24F-0090N and Hardware Superstore contract No. GS-06F-0008P to provide a range of wireless product selections to federal agencies worldwide.

Under the terms of the contract, federal buyers will receive GSA-specific pricing and purchasing terms while experiencing the advantages of working with a total source supplier of wireless support products. The contract authorizes over 10,000 GSA buying organizations to purchase approximately 7000 items from TESSCO. Wireless equipment available under the GSA schedules includes amplifiers, spectrum analyzers, data network analyzers, filters, power-measurement tools, bench/test equipment, repeaters, and multimeters. These schedules complement the ability of federal buyers to purchase from TESSCO's total 34,000-item offering on the open market.

Motorola, Inc. Commercial, Government, and Industrial Solutions Sector (CGISS)—Announced that it has been chosen by the Greater Copenhagen Authority to supply and operate a TETRA (TErrestrial Trunked RAdio) digital radio-communications network in the Copenhagen, Denmark metropolitan area for an improved transit system.

The contract includes the TETRA network, which will serve 1200 buses, 2 ships, and 30 trains, and inclusive of 100 TETRA handsets for use by traffic inspectors in the metropolitan area. In addition, Motorola has been awarded a service contract for a minimum period of six years. The network will carry both voice and data and will help to provide smoother operations in areas such as resource management, customer information (arrival times, locations), and security systems. It will also improve communications between the different modes of transport.

The contract signifies the official establishment of TETRA in Copenhagen, which has been planned since two licenses were awarded by the government in October 2001, one of which was Awarded to TetraNet, a Motorola company.

The network is scheduled to be deployed in two phases—the first with voice capabilities in the second quarter of 2004, and the second with data capabilities 12 months later.

Advanced Control Components, Inc.—Has been awarded a contract in excess of $1 million to design, develop, and manufacture switch assemblies to be used in EW application.

FRESH STARTS

RF Micro Devices, Inc.—Announced that it has shipped its 300 millionth power-amplifier (PA) module. RFMD is the fastest company in the industry to ship 300 million PA modules.

ANADIGICS, Inc.—Has acquired the assets utilized in the wireless handset power-amplifier (PA) business previously conducted by Tavanza, a subsidiary of Celeritek, to broaden its CDMA product line and to accelerate its penetration into strategic handset OEM customers. The agreement includes $3 \times 3 \times 1$-mm CDMA power amplifiers, technology, and intellectual property, as well as the recruitment of key RF engineering personnel related to the product line. Celeritek announced in September 2003 that they were leaving the handset PA business to focus on GaAs-based subsystems and semiconductors for the defense markets.

Fiber-Span LLC and Richardson Electronics—Announced that they have signed a distribution agreement.

Under the terms of the agreement, Richardson will operate as the sole distributor in Europe, the Middle East, and South Asia (EMEA), representing Fiber-Span's complete line of modules, subsystems, and systems addressing the commercial, public-safety, and defense/military markets. Fiber-Span will continue to extend its sales coverage and, at the same time, plans to offer better customer service by utilizing Richardson's sales-support and logistics-support networks.

Micronetics, Inc.—Was ranked at number 55 on the list of "Best Small Companies" that was published in the October 27, 2003 issue of *Forbes* magazine.

Andrew Corp.—Announced that it has made an investment in Andes Industries, Inc. and its principal operating subsidiary PCT International, a supplier of optical and RF equipment for the broadband cable market. The financial terms of the investment are not being disclosed.

Maury Microwave Corp.—Signed an agreement with Modelithics, Inc. of Tampa, FL, to advance the application of load/source pull measurement more efficient non-linear device modeling and circuit design.

Under the agreement, applications of load/source pull measurements will be advanced using the latest Maury Microwave Automated Tuner System (ATS).

Microfabrica, Inc.—Has joined forces with Itochu Corp. and Sumitomo Corp. to provide local support in the Japanese market.

Under the terms of the agreements, Itochu and Sumitomo will serve as certified distributors of Microfabrica's EFAB™ micro-manufacturing technology and will also provide technical support in the Japanese market. MRF

BLAND

ITT Cannon Names Bland To VP And Controller Spot

ITT Industries, Cannon has appointed DAVID BLAND to the position of vice president and controller, located at the Santa Ana, CA facility. Prior to joining Cannon, Bland served as senior vice president of finance and administration at a subsidiary of Flextronics.

Andrew Corp.—J.C. HUANG, PH.D. to the position of chief technology and strategy officer; formerly managing director and general partner at Ericsson Venture Partners.

Global Crossing—ANTHONY CHRISTIE to chief marketing officer; formerly senior vice president for offer and product management.

AccelChip—TOM FEIST to vice president of marketing; formerly group director of product marketing for Mentor Graphics, Inc.

Optical Cable Corp.—NEIL WILKIN to chairman and CEO, remaining as president; formerly CFO. Also, TRACY SMITH to vice president and CFO; formerly controller.

Voice Signal Technologies—RICHARD J. GERUSON to CEO; formerly senior vice president at Nokia.

SMTA—JEFF ANWEILER to vice president of SMTA's Empire chapter in upstate New York; continues as technical sales manager at Indium Corp.

IceFyre Semiconductor, Inc.—SEAN BURKE to the board of directors; remains as vice president and general manager for Mobile & Desktop Solutions at Iomega Corp.

Powerhouse Technologies Group, Inc.—R.B. "ROB" HUTCHINSON to the board of directors; formerly president and chief technical officer at eCharge.

FKI Logistex Alvey Systems—GEORGE REYHER to the position of account manager for Latin America; formerly employed with the Krones Group and Barry-Wehmiller.

FKI Logistex White Systems—RICHARD LANPHEARE to regional sales manager; formerly product manager for vertical carousels and vertical lifts. Also, DANIEL VANHOOSER to the position of regional sales manager; formerly employed with Haggard & Stocking Associates, Storage & Office Systems, and IDS Engineering.

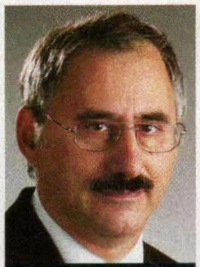
PXI Systems Alliance (PXISA)—LOOFIE GUTTERMAN to president; continues as president of Geotest-Marvin Test Systems, Inc.

Mimix Broadband, Inc.—ERIK VAN DER KAAY to the board of directors; formerly president and CEO of Datum, Inc.

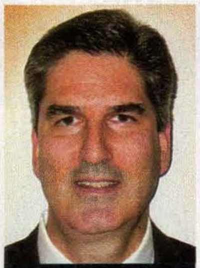
Entela, Inc.—STEVEN PODVOLL to electrical manager for the Detroit-area Automotive Testing Laboratory in Livonia, MI; formerly engineering manager for Sound Systems/Ford Programs at Alpine Electronics of America.

Brush Ceramic Products, Inc.—JOHN SCHEATZLE to general manager; formerly manufacturing manager for Alloy Bulk Products at the company's Elmore, OH facility.

Rohde & Schwarz—ROLAND STEFFEN to head of the Test and Measurement Division and to Corporate Management; formerly director of the Mobile Radio T&M Products Subdivision.



STEFFEN



ROSNER

Janos Technology Corp.—BRETT D. ROSNER to the position of president; formerly director of Santa Barbara Focalplane, a Lockheed Martin Missile and Fire Control Business. MRF

▸SHORT COURSES

Basic Telephony and Digital Switching
January 6-9, 2004 (Madison, WI)
The University of Wisconsin-Madison, Department of Engineering Professional Development
(800) 462-0876
e-mail: custserv@epd.engr.wisc.edu
Internet: http://epdweb.engr.wisc.edu/webF704

UCLA Extension Short Courses
All courses at UCLA Extension Building, Los Angeles, CA
January 12-14 *FPGAs for Digital Signal Processing and Communications*
January 15-16 *DSP-Based Carrier and Timing Recovery Techniques in Digital Modems*
January 21-23 *Using Patterns, Frameworks, and COBRA to Develop Object-Oriented Distributed Applications*
January 27-30 *Project Scheduling Principles and Strategies*
For further information, contact:
Dr. William R. Goodin
UCLA Extension, Short Course Program
10995 Le Conte Ave., Suite 542
Los Angeles, CA 90024-2883
(310) 825-5010, FAX: (310) 206-2815
e-mail: bgoodin@unex.ucla.edu
Internet: www.uclaextension.edu/shortcourses

Technology Strategy for R&D and Product Development
March 25-26, 2004 (Pasadena, CA)
Course Location: California Institute of Technology Industrial Relations Center
For further information, contact:
California Institute of Technology
Industrial Relations Center, I-90
Pasadena, CA 91125-9000
(626) 395-4043, FAX: (626) 795-7174
e-mail: execedu@caltech.edu
Internet: www.irc.caltech.edu

Antenna Parameter Measurements By Near-Field Techniques
April 20-22, 2004 (Boulder, CO)
National Institute of Standards and Technology (NIST) Boulder Laboratories
To register, contact:
Wendy McBride, Conference Manager
NIST, MS 346
325 Broadway
Boulder, CO 80305
(303) 497-4500, FAX: (303) 497-5208
e-mail: Wmcbride@boulder.nist.gov
Internet: www.nist.gov/public_affairs/confpage/blconf.htm

▸MEETINGS

CONMET Conference & Expo
January 26-29, 2004 (Washington, DC)
Washington Convention Center
Conference is January 26-29
Expo is January 27-29
(866) COMNETX
Internet: www.comnetexpo.com

Wireless Systems Design Conference and Expo 2004 co-located with the Military Electronics Show West 2004
March 8-10, 2004 (San Diego, CA)
San Diego Convention Center
To exhibit, contact Dave Rodriguez at (203) 559-2805 or drodriguez@penton.com
For marketing opportunities, contact Amy Orsini at (203) 559-2966 or aorsini@penton.com
FAX: (203) 559-2840
Internet: www.wsdexpo.com

CeBit 2004
March 18-24, 2004 (Hannover, Germany)
(609) 987-1202 ext. 211
e-mail: cebit@hfusa.com
Internet: www.hfusa.com/cebit

electronicaUSA with the Embedded Systems Conference
March 29-April 1, 2004 (San Francisco, CA)
Moscone Convention Center
For further information, contact:
Linsy Reese, CMP Media LLC
(415) 947-6645, FAX: (415) 947-6009
e-mail: lreese@cmp.com
Internet: www.electronicaUSA.com

RF & Hyper Europe 2004
March 30-31, April 1, 2004 (Paris, France)
Paris Expo—Porte De Versailles—Hall 2.2
For further information, contact:
BIRP
11, rue du Perche
75003 Paris, France
+33 1 44 78 99 30, FAX: +33 1 44 78 99 49
e-mail: hyper@birp.fr
Internet: www.birp.com/hyper

2004 International Conference on Compound Semiconductor Manufacturing Technology
May 3-6, 2004 (Miami Beach, FL)
Sheraton Bal Harbour Beach Resort
e-mail: info@gaasmantech.org
Internet: www.gaasmantech.org or www.csmantech.org

2004 Symposium on VLSI Technology
June 15-17, 2004 (Honolulu, HI)
Hilton Hawaiian Village
e-mail: vlsi@vlsisymposium.org
Internet: www.vlsisymposium.org

▸CALL FOR PAPERS

Wireless and Microwave Technology Conference 2004
April 15-16, 2004 (Clearwater, FL)
Radisson Sand Key
Extended Abstracts Due: January 1, 2004
Author Notifications: February 1, 2004
Final Papers Due: February 25, 2004
Authors are asked to submit an extended abstract (maximum 2 pages) electronically to arslan@eng.usf.edu. The preferred file formats are PDF and MS Word.
Internet: http://ee.usf.edu/WAMI/forum/2004/home.html

EBG Antennas Show Potential At Millimeter Waves

ELECTROMAGNETIC-BANDGAP (EBG) technology offers tremendous potential for creating high-performance microwave and millimeter-wave antennas and other components. EBG technology [often referred to as photonic-bandgap (PBG) technology] involves the fabrication of three-dimensional periodic structures formed by mechanically drilling into blocks of dielectric material. These structures make it possible to manipulate the propagation of electromagnetic (EM) waves with great precision, and could form the basis for a new generation of microwave and millimeter-wave antennas and passive components. Peter de Maagt and co-workers from the Electromagnetics Division of the European Space and Research Technology Centre (ESTEC) of the European Space Agency (Noordwijk, The Netherlands) report on the potential of this technology, notably for miniature patch antennas, antenna arrays, planar filters, and frequency-selective materials. The drive for cost-effective broadband communications systems, for fixed and mobile Internet access, for example, has increased interest in technologies like EBG which has the potential to support affordable millimeter-wave components. With the US Federal Communications Commission (FCC) recently releasing bandwidth in the 80-to-90-GHz range for broadband commercial communications, manufacturers of high-frequency components are faced with the challenge of creating new products within stringent cost limits. The researchers report on the use of EBG crystalline materials for tunable bandgap antennas, miniature patch and dipole antennas with responses through 500 GHz, highly selective filters, and low-loss waveguide. See "Electromagnetic Bandgap Antennas and Components for Microwave and (Sub)Millimeter Wave Applications," *IEEE Transactions on Antennas & Propagation,* October 2003, Vol. 51, No. 10, p. 2667.

Microstrip Patch Antenna Grabs Three Bands

RAPIDLY SPREADING WIRELESS applications now pose the problem of installing multiple antennas for difference services, such as wireless local-area networks (WLANs) and Global Positioning System (GPS) on the same end-product. Fortunately, Jeen-Sheen Row of the Department of Computer and Communication Engineering at the Chien Kuo Institute of Technology (Chang-Hua, Taiwan, Republic of China) has developed an innovative triple-band microstrip patch antenna capable of dual-band WLAN reception at 2400 to 2483 MHz and 5150 to 5850 MHz and GPS operation at 1575 MHz. The compact two-element patch antenna consists of a single-feed planar inverted-F antenna (PIFA) with a U-shaped slot for dual-band WLAN operation and a corner-truncated square microstrip patch antenna for GPS operation. The microstrip patch antenna is fabricated on low-cost FR4 material with 1.6-mm thickness and dielectric constant of 4.4. The side length of the square patch is 45.4 mm and the side length of the truncated corners is 5.2 mm. The feed position of the GPS antenna is placed along the x-axis to receive right-hand circular-polarization signals; the distance of the probe feed from the patch center is 12 mm. Measurements on the fabricated component reveal that the antenna elements are isolated by more than 25 dB, with impedance bandwidths of 6.9 percent for the lower WLAN band, 14.2 percent for the upper WLAN band, and return loss of better than 20 dB for the GPS antenna at its design frequency of 1575 MHz. See "A Triple-band Microstrip Patch Antenna," *Microwave and Optical Technology Letters*, July 20, 2003, Vol. 38, No. 2, p. 120.

Phase Modulation Supports DAB In FM Band

CONTINUOUS PHASE MODULATION may provide the means to transmit digital-audio-broadcast (DAB) signals over standard frequency-modulated (FM) radio frequencies from 88 to 108 MHz. According to a report by Gerrit de Boer and associates from the University of Hannover, Institut fur Allgemeine Nachrichtentecknik (Hannover, Germany), it is possible to broadcast DAB signals simultaneously with FM signals using adjacent channels, continuous phase modulation, and a reduced-state sequence estimator. The continuous phase modulation, which allows the use of low-cost nonlinear power amplifiers, supports data rates to 200 kb/s inside a 200-kHz FM channel, sufficient for transmission of digital compressed audio signals with compact-disc (CD) quality. Field tests were performed with a real digital transmission system transmitting in a public system and using a personal-computer-based mobile receiver. See "Digital Audio Broadcasting in the FM Band Based on Continuous Phase Modulation," *IEEE Transactions on Broadcasting*, September 2003, Vol. 49, No. 3, p. 293.

DESIGN

Understanding Ultra Narrowband Modulation

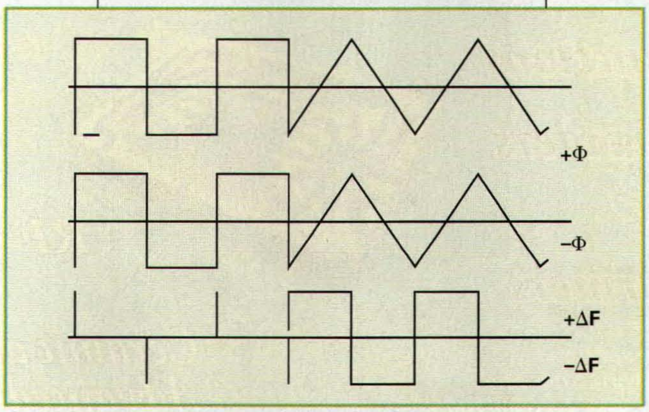
Ultra narrowband modulation formats, in which sidebands are minimized, provide extremely bandwidth-efficient methods of transmitting high-data-rate information.

Modulation advances have fueled more efficient use of bandwidth, although conventional modulation formats still require allowance for upper and lower sidebands around the carrier frequency. Ultra narrowband modulation, however, is an efficient form of transmitting information without using sidebands. The modulation format, which is also known as very minimum sideband keying (VMSK) or

HAROLD R. WALKER
President
Pegasus Data Systems, 78 Oliver Ave., Edison, NJ 08820; FAX: (732) 494-0372,
e-mail: pegasusdat@aol.com.

minimum sideband (MSB) modulation, has been in development since 1985. Although stalled since that time due to the lack of practical filters, the modulation method is now available to system developers through the use of filtering techniques with zero group delay.

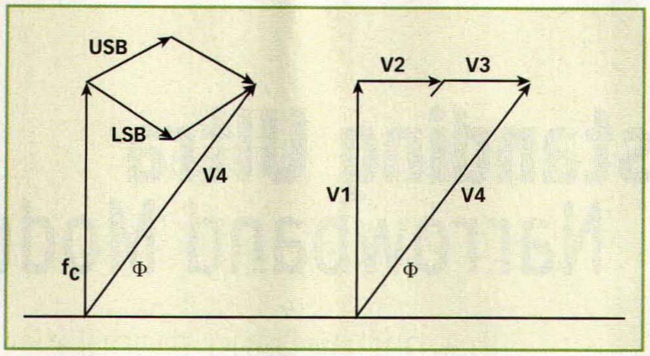
A review of more conventional modulation formats, such as frequency modulation (FM) and phase modulation (PM), may help when attempting to understand MSB modulation. For example, in conventional modulation formats, changes in frequency and phase occur gradually **(right-hand side of Fig. 1)**, compared to the abrupt changes in frequency and phase of MSB modulation **(left-hand side of Fig. 1)**. MSB digital modulation utilizes a coded baseband with abrupt edges; that is, the rise/fall times are as abrupt or near zero as possible. Some resistive-capactive (RC) rise time is inevitable, due to slew rates in integrated circuits (ICs) and other parts of the transmitter/receiver circuitry. In practice, these changes occur during one cycle of the intermediate frequency (IF).



1. These modulated waveforms show the difference between abrupt changes in amplitude and phase (left-hand side) and more gradual transitions (right-hand side).

For example, the frequency resulting from a modulating input signal is $F = F_{carrier} + \Delta f$, where the modulation frequency, Δf, can be calculated from the basic relationship of $\omega t = \Phi = 2\pi ft$. The modulation frequency can also be rewritten in derivative form as $\Delta f = \Delta\Phi/2\pi t$. The rise/fall time, t, is fixed by the circuit parameters. During rise/fall

times for abrupt phase modulation, there is a large $\Delta\Phi/\Delta t$ which causes large Δf (almost infinite) for a very short duration (about 1 cycle at RF). At all other times, $\Delta\Phi$ is zero and the frequency is constant at $F = F_{carrier}$. A phase detector using $F_{carrier}$ as a phase reference will detect the phase changes as positive and negative voltages, but will ignore large Δf. In this case, consider $\Delta\Phi$ as being zero for most of the bit (information) period.



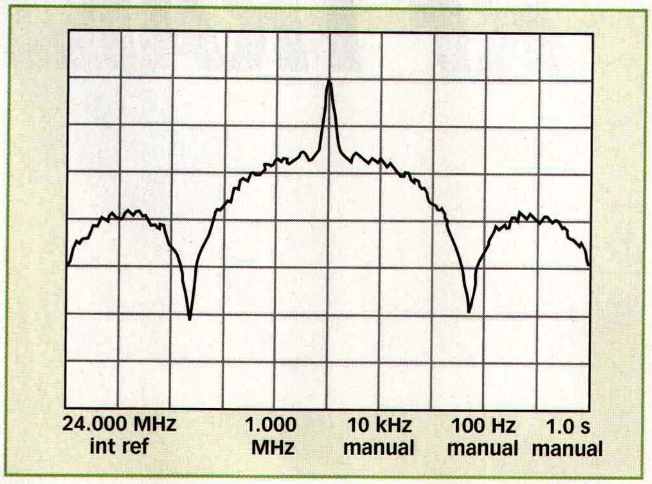
2. Phase-modulated signals include an upper sideband (USB) and a lower sideband (LSB) and can be represented by a series of vectors.

The situation is different for the waveform in the right-hand side of Fig. 1. In that case, $\Delta\Phi$ has a finite value and lasts for the entire period of the phase change. There is a definite change in frequency for the phase change period. Armstrong[2] used this concept to produce FM from PM in 1936. If $\Delta\Phi/\Delta t$ is caused by a sine wave, the resulting FM is a cosine wave, since FM is the derivative of PM.

The abrupt phase change and resulting frequency change in the left-hand side of Fig. 1 was noted by Professor Howe in 1939.[1] The observation was not applied since digital-modulation techniques were not in use at that time, and the filters needed to take advantage of the abrupt phase changes were not available.

Any bandpass filter used at the transmitter for ultra narrowband (MSB) modulation must exhibit zero group delay to pass the instantaneous phase changes, though it may lack the bandwidth required to pass instantaneous changes in frequency. To all intents and purposes, there is no measurable frequency change, but there is a phase change in the carrier that is maintained constant between the rise and fall times. A conventional, or Nyquist filter, has group delay and rise time. This causes the phase modulation to spread out over time, and the result is FM (right-hand side of Fig. 1).

According to accepted practice using PM to generate FM (the Armstrong method), a carrier and upper and lower



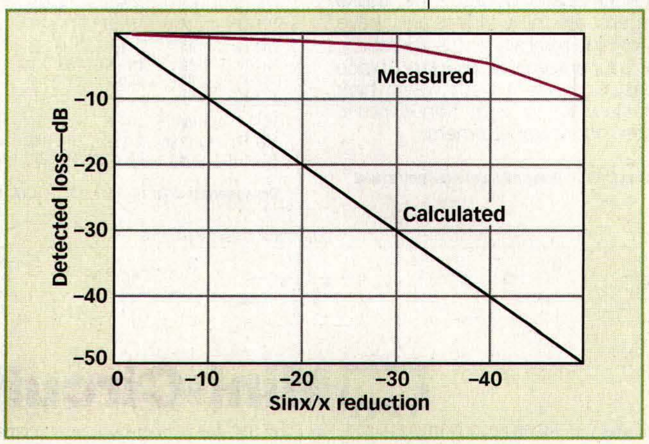
3. This waveform results from a rectangular waveform with NRZ baseband code and 90-deg. abrupt phase modulation.

sidebands are required **(Fig. 2)**.[2] The vectors for the upper and lower sidebands counter-rotate in phase, reaching a maximum in either direction when they are at the same phase. The upper sideband (USB) is a signal higher in frequency than the carrier by an amount equal to the modulation frequency. The lower sideband (LSB) is lower in frequency than the carrier by the same amount. This gives rise to Bessel products, which are necessary to cause the vector V4 to shift in phase. There are three or more different frequencies involved to produce the phase shift, Φ.[3]

The equivalents of the USB and LSB are seen as vectors V2 and V3 when using abrupt phase modulation. They must maintain the phase shift, Φ, at a constant angle, hence they cannot rotate, but can only reverse. If they do not rotate, they are not at different frequencies, but at the same frequency as the carrier V1.

Abrupt phase-angle modulation does not require any frequencies other than the carrier. There are no Bessel products or other frequencies required to produce the phase shift. This is obvious from the mathematics. If the modulation frequency, Δf is equal to $\Delta\Phi/2\pi t$, and the change in the phase shift, $\Delta\Phi$, is zero, then Δf is zero. The level of the J_n Bessel products, as referenced from a Bessel function table, is determined by $\beta = \Delta\Phi$. If $\beta = 0$, there are no Bessel products other than the J_0 product.[3]

When using a coded baseband to produce the rectangular waveform in the left-hand side of Fig. 1, and using 90-deg. abrupt phase modulation, the spectrum of **Fig. 3** would result. Non-return-to-zero (NRZ) information from a CMOS driver is used to avoid having an unfamiliar baseband code for this example (with a data rate of 270 kb/s using random data). The dome-shaped base of the spectrum is the sum of the

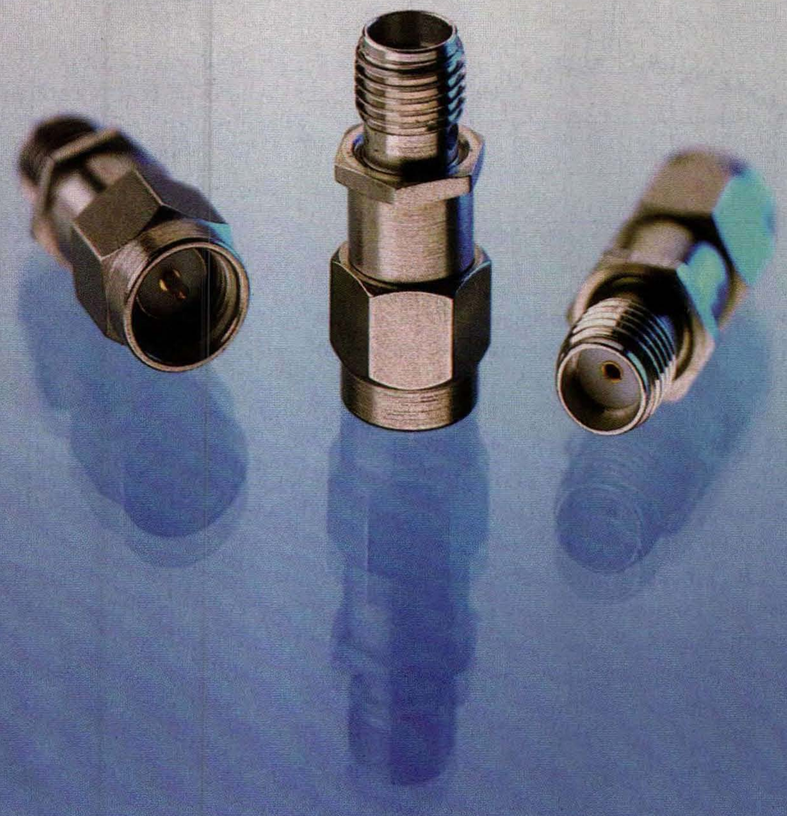


4. This plot compares calculations of detected phase-angle output levels with actual measurements.

Aeroflex / Inmet's New AHC Attenuator Series, Production Pricing at Prototype Volumes

AEROFLEX
INMET

An ISO 9001 Certified Company



This new generation of SMA attenuators offer performance at truly affordable pricing starting at **$12.45 in quantities of 1-99 pieces**, factory direct.*

Ideal for Wireless LAN, Wireless Infrastructure, E-911 Kits, WiFi, and Indoor Distribution Applications; the robust design has been qualified to the shock and vibration profiles required in MIL-A-3933. These 2 Watt units operate from DC to 6 GHz with a 1.20:1 max VSWR while providing excellent attenuation flatness. The AHC series is offered in dB values of 1-12, 15, 20 and 30 dB.

Inmet also manufactures terminations, DC blocks, bias tees, equalizers and a full line of cable adapters.

For more information call your Aeroflex / Inmet representative, or 734-426-5553 or download a data sheet from **www.aeroflex-inmet.com.**

*Subject to Inmet minimum order policy and terms and conditions.

AEROFLEX
A passion for performance.

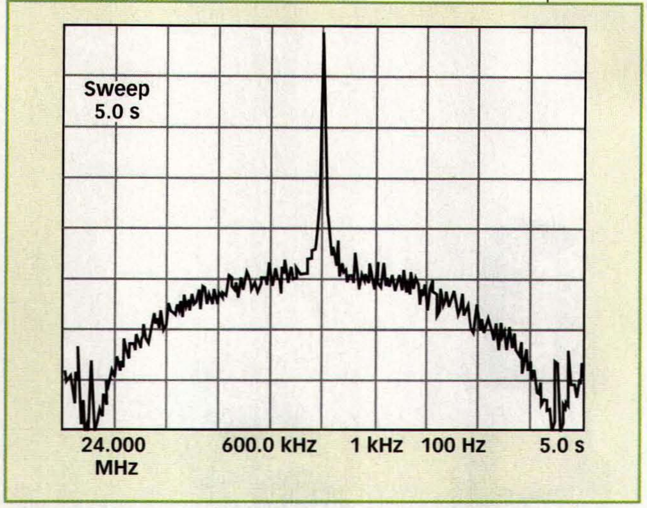
Fourier frequencies associated with random NRZ data. Although the Fourier products are amplitude products only, they do appear using this modulation method. They do not cause any phase shift and can be reduced by zero-group-delay filtering.

When Bessel products are present, the phase angle is related to the level of the Bessel sidebands by the relationship $2J_1 = \sin\Phi$ (from ref. 3). If this relationship were to hold true for the Fourier products, the phase-detected output would decrease linearly with the decrease in the Fourier sinx/x product level. Using this formula to calculate the assumed decrease in phase angle, and comparing this with the actual detected output level, it can be seen that the detected phase angle has almost no change.

The Fourier products are sin/x/x products that can be ignored since they produce no PM. The measured phase angle output level from the phase detector is almost independent of these products as seen by the measured line. Calculated and measured results are show in **Fig. 4**. Adding several cascaded stages of zero-group-delay filtering does cause some loss, although optimum tuning will yield a higher output level than shown in Fig. 4.

Fourier sinx/x products have no relationship to the detected phase angle. The zero-group-delay filters used with MSB modulation have a bandwidth that is only 2 to 3 kHz wide, resulting in an excellent signal-to-noise relationship. The narrow filter bandwidth also makes it possible to pass a single frequency (J_0), while rejecting the Fourier sinx/x sidebands.

The spectrum shown in **Fig. 5 and 6** has a measured phase angle level, from the detector, that is only 2 dB less than the measured level when no filter is used. The zero-group-delay filter reduces the Fourier product levels by 30 dB. The level remains near that for the unfiltered signal, even when the Fourier sidebands are reduced further. Figure 6 shows Fourier sidebands that a reduced by nearly 60 dB using three cascaded filter sections, while the detected phase change output level is only reduced by 10 dB or less compared to Fig. 4. NRZ data was used as the input, with random data and zero group delay filtering to reduce the sinx/x Fourier products. There is some loss because the cascaded filter sections do introduce a small amount of group delay, which reduces the detected phase angle.



5. This spectrum has a detected phase-angle level that suffers only 2-dB loss from zero-group-delay filtering that achieves 30-dB sideband suppression.

The Fourier sinx/x level has the characteristics of noise, the level of which varies with the bandwidth. The spectral plots of Figs. 3, 5, and 6 were created with different spectrum analyzer resolution bandwidths. **Figure 7** shows two filters that use the crystal in the parallel mode as a large pure resistance for a single frequency at resonance (shunt and bridge). Figures 7(c) and 7(d) show the equivalent circuit while Figs. 7(e) and 7(f) show the impulse responses. These circuits have a rise time determined by other parts of the circuit, not by the crystal and the coupling capacitor. The crystal does not act as a bandpass device in the circuit, but passes the abruptly modulated input signal around it in the manner of an RF differentiator. The signal is passed via the capacitor, ignoring the resistor. For frequencies other than the single frequency at resonance, the circuit sees the reactance of the crystal as a load. The crystal acts as a capacitor in a capacitor voltage divider circuit, with other impedance values making it an integrator, not responsive to short bursts.

What is the performance of the crystal filter in terms of bandwidth efficiency? Bandwidth efficiency is defined as the bit rate per bandwidth, such as 2 b/s/Hz. Assuming the 2-to-3-kHz 3-dB bandwidth of the crystal filter, the bandwidth efficiency is very high. For a bit rate of 270 kb/s at that crystal filter bandwidth, the bandwidth efficiency is 100 b/s/Hz.

The signal-to-noise ratio (SNR) can be determined from the formula given by Feher.[4]:

$$SNR = \beta^2 C/N \text{ or}$$
$$SNR = \beta^2(\text{bit rate/filter bandwidth})E_b/N$$

where:

E_b/N = the bit energy to noise ratio.

In this equation, β is ±45 deg. or 0.79 rads. For a bit rate of 270 kHz and a 3-dB filter bandwidth of 2.7 kHz, the values are:

$$SNR = (0.79)^2(270/2.7)E_b/n \text{ or}$$
$$SNR = 62_b/n$$

If binary phase-shift keying (BPSK) is assumed as a modulation reference standard, with $SNR = E_b/n$, then MSB is better in SNR than BPSK by a significant amount (shown to be a valid assumption through measurements of BER using VMSK). The multiplier (62) indicates that VMSK is actually SNR-efficient enough to be competitive with orthogonal-frequency-division-multiplex (OFDM) modulation, which has a large frequency spread. However, the large multiplier cannot be achieved in practice, since VMSK is subject to a lower limit similar to the FM knee at about 6 dB.

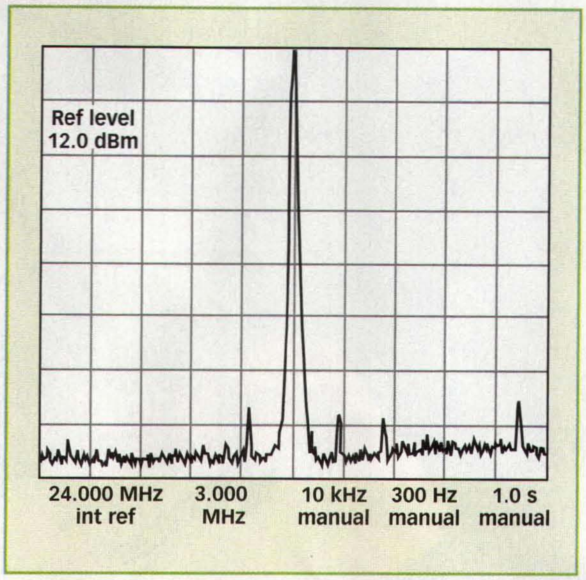
Upon casual observation, VMSK may appear to violate Shannon's Limit, although if this were the case, VMSK


SPLITTER
HYBRID
COUPLER
SYNSTRIP®
TECHNOLOGY
ATENT PENDING
or additional information, contact Synergy's sales and application team.
01 McLean Boulevard, Paterson, NJ 07504
hone: (973) 881-8800 Fax: (973) 881-8361
-mail: sales@synergymwave.com
orld Wide Web: www.synergymwave.com
SYNERGY®
MICROWAVE CORPORATION

would not work. It does violate Carson's Rules, and does not require the Nyquist bandwidth. Parameter C, the system channel capacity, is obtained by multiplying the number of information samples per second by the information per sample (p. 324 and Eq. 6-134 of ref. 5). In ref. 5, Schwarz defines channel capacity (Eqs. 6-125 and 2-149) as:

$$C = (1/\tau)\log_2 n$$

Using different terms, the classic form of Shannon's equation can be expressed as:



6. This MSB spectral plot was created with NRZ as the input signal passed through three cascaded, random-group-delay filter sections to reduce Fourier sidebands by nearly 60 dB.

$$F_b = W\log_2[1 + (C/N)]$$

where:

$W = 1/\tau$ (the sampling rate)

C/N = (the bit rate)/(filter bandwidth) (E_b/N_0)

$f_b = (1/\tau)\log_2[1 +$ (bit rate)/(filter bandwidth) $(E_b/N_0)]$

β^2 = modulation loss (that reduces the value of E_b.

Therefore,

$$f_b = (1/\tau\log_2[1 + \text{(bit rate)/(filter bandwidth)}\ (E_b/N_0)]$$

where:

$1/\tau \geqslant f_b$(according to Nyquist sampling theory).

Using the figures above for the carrier-to-noise (C/N) ratio,

$$F_b = (1/\tau)\log_2[1 + (100)(0.62)(E_b/N_0]$$
$$= (1/\tau)\log_2[1 + 62(E_b/N_0]$$

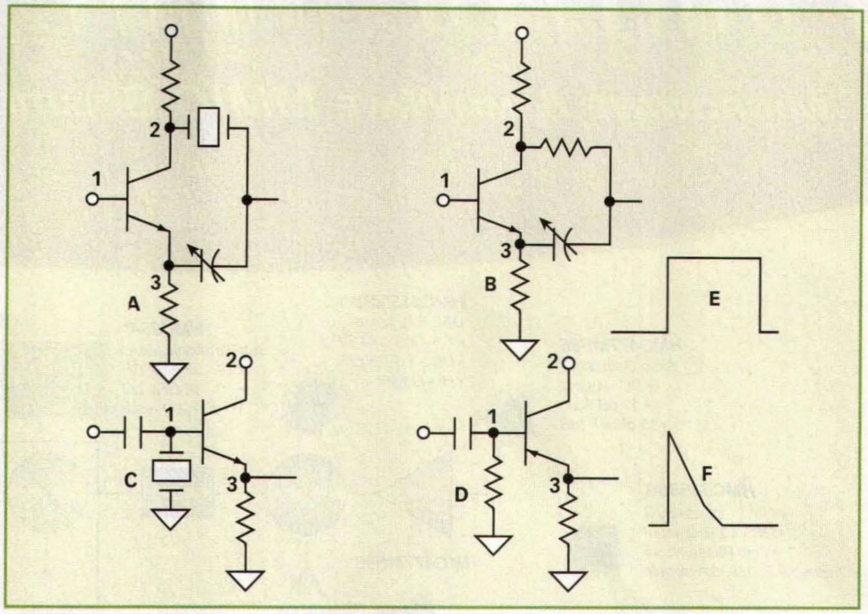
The angle β from ±45 deg. modulation is 0.79 rads and $\beta^2 = 0.62$ (if perfect). As seen in Fig. 4, there is some loss, so it may be lower with many stages of filtering. A 10-dB loss would reduce the value to about 0.25. Until $\beta = 0.1$, measurements show MSB to be better than BPSK. Unfortunately, it is not possible to obtain a large multiplier for C/N. The MSB method used here is a PM method subject to a lower limit at the FM knee (at about 6 dB).

Note the similarity of the MSB SNR to Shannon's Limit: For a SNR of 0 dB, the same limit is reached, and the bit-error rate becomes 50/50. The error probability (P_e) is based on the SNR:

$$P_e = 0.5\ \text{erfc}[\text{SNR}]^{0.5}$$

Research and development on ultra narrowband modulation methods started at Pegasus Data Systems (Edison, NJ) in 1985 with a method known as variable-phase-shift-keying (VPSK) modulation. Unfortunately, VPSK suffered from some bandwidth spread and was difficult to filter. The modulation method was abandoned in 1996 in favor of VMSK. Adhering to the accepted theory that all modulation is in the sidebands, VMSK used a proprietary baseband code to compress the bandwidth to a single spectral line. This baseband was then used to modulate a carrier, yielding two sidebands. One sideband was removed so that the remaining sideband was a single frequency with abrupt phase changes (much like the MSB cur-

rent carrier-altering approach). VMSK is therefore a subclass of MSB. In December 2000, the first carrier-altering method was introduced.[7] Referred to as "pulse-position phase-reversal keying" (3PRK), this MSB subclass has been successfully used on microwave links and in cellular-telephone tests. Later variations are now being used on in cordless telephones and cable-television (CATV) systems. Reference 8 provides information on circuitry for encoding and decoding circuitry for one form of MSB modulation presently in use on microwave links. Additional information on VMSK modulation can be found on the website at www.VMSK.org. MRF



7. Filters with zero rise time and group delay were used to produce this spectral plot.

REFERENCES

1. Professor Howe, as published in K.R. Sturley, *Frequency Modulation*, Chemical Publishing Co., Brooklyn, NY (from "Wireless Engineer," November 1939, p. 547.

2. E.H. Armstrong, Proceedings of the IRE, May 1936.

3. A. Hund, *Frequency Modulation*, McGraw-Hill, New York, 1942.

4. Kamilo Feher, *Wireless Digital Communications*, Prentice-Hall, Englewood Cliffs, NJ.

5. Mischa Schwartz, *Information Transmission, Modulation and Noise*, McGraw-Hill, New York.

6. R.E. Best, *Phase Locked Loops*, McGraw-Hill, New York.

7. H.R. Walker, United States Patent No. 6,445,737, "Digital Modulation Device in a System and Method of Using the Same," (covers 3PRK and MCM).

8. J. Pliatsikas, C. Koukourlis, J. Sahalos, and H.R. Walker, "VMSK Modulation Boosts Wireless Communications Efficiencies," *Wireless Systems Design*, January 1998.

Design Inset-Fed Microstrip Patch Antennas

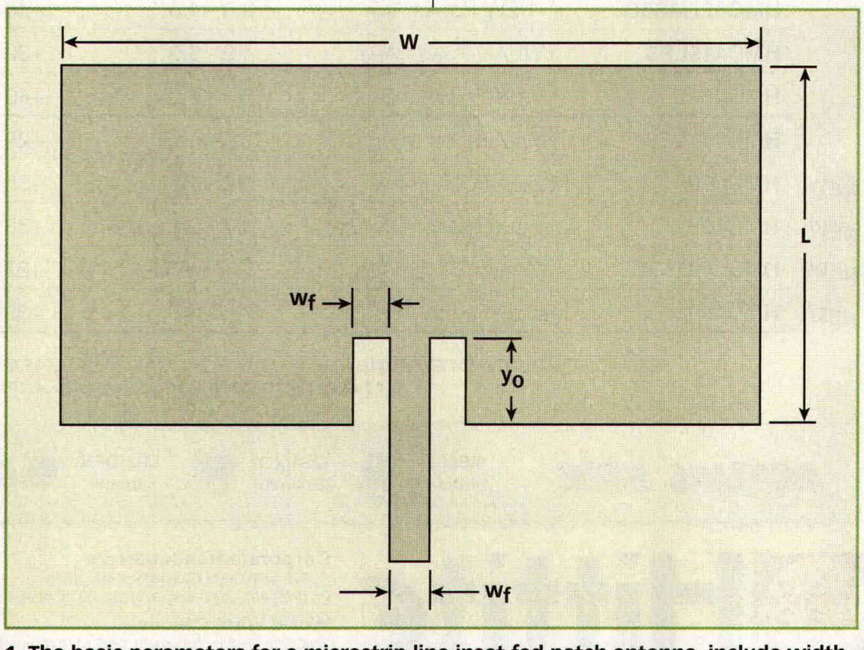
This design approach helps analyzer microstrip inset-fed patch antennas and helps to locate the exact inset length for 50-Ω input impedance.

M. RAMESH
Senior Staff Engineer
Motorola, Penang, Malaysia.

K.B. YIP
Member of the Technical Staff
Motorola, Penang, Malaysia; (60) 4-6302552, FAX: (60)4-612-4065, Internet: www.motorola.com.

Low-profile, low-cost antennas support the operation of many modern communication systems. Microstrip patch antennas represent one family of compact antennas that offers the benefits of a conformal nature and the capability of ready integration with a communication system's printed circuitry. By using a straightforward transmission-line model, it is possible to accurately model and analyze microstrip-line inset-fed patch antenna designs. In addition, by applying a curve-fit formula, it is possible to locate the exact inset length needed for a 50-Ω input impedance.

The feed mechanism plays an important role in the design of microstrip patch antennas. A microstrip patch antenna can be fed either by coaxial probe or by an inset microstrip line. Coaxial probe feeding is sometimes advantageous for applications like active antennas, while microstrip



1. The basic parameters for a microstrip-line inset-fed patch antenna, include width (W), length (L), and distance of feed line from the edge (y_0).

line feeding is suitable for developing high-gain microstrip array antennas. In both cases, the probe position or the inset length determines the input impedance.

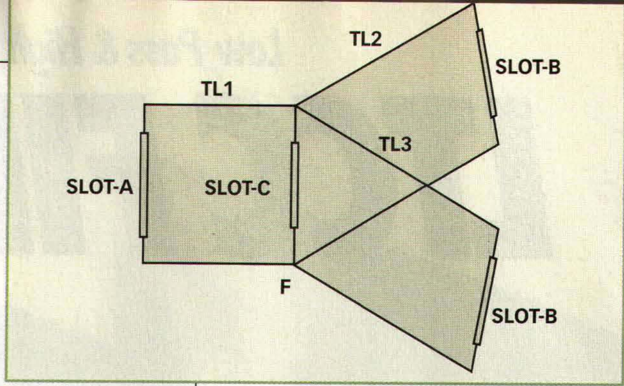
The input impedance behavior for a coaxial probe-fed patch antenna has been studied analytically by means of various models, including the transmission-line model and the cavity model, and by means of full-wave analysis.[1-3] Experimentally and theoretically, it has been found that a coaxial-probe fed-patch antenna's input impedance exhibits behavior that follows the trigonometric function:

$$\cos^2[\pi(y_0/L)]$$

where:

L = the length of the patch and

y_0 = the position of the feed from the edge along the direction of the patch length L.



2. By assuming a patch antenna of four sections, it can be modeled as transmission lines loaded by radiating slots of different lengths.

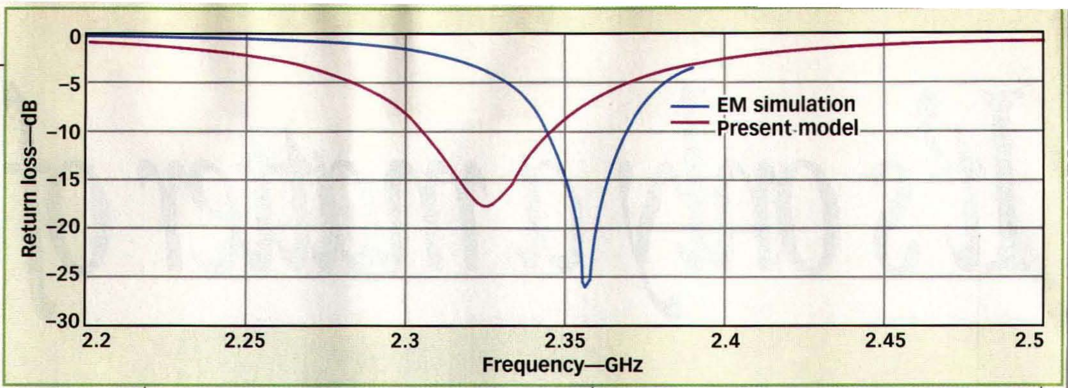
On the other hand, it has been found experimentally[4] that on low-dielectric-constant materials, the input impedance of an inset-fed probe antenna exhibits fourth-order behavior following the function:

> ***The feed mechanism plays an important role in the design of microstrip patch antennas.***

$$\cos^4[\pi(y_0/L)]$$

Fortunately, a simple analytical approach has been developed using the transmission-line model to find the input impedance of an inset-fed microstrip patch antenna. Using this approach, a curve-fit formula can

be derived to find the inset length to achieve a 50-Ω input impedance when using modern thin dielectric circuit-board materials.



3. Although the resonate frequency predicted by the transmission-line model differs somewhat from results generated by an EM simulator, the shapes of the return-loss responses from both approaches are very similar.

Figure 1 is a graphical depiction of an inset-fed microstrip patch antenna. The parameters ϵ_r, h, L, W, w_f, and y_0, respectively, are used to denote substrate dielectric constant, thickness, patch length, patch width, feed-line width, and feed-line inset distance. The input impedance of an inset-fed microstrip patch antenna depends mainly on the inset distance, y_0, and to some extent on the inset width (the spacing between the feed line and the patch conductor). Variations in the inset length do not produce any change in resonant frequency, but a variation in the inset width will result in a change in resonant frequency. Hence, in the following discussion, the spacing between the patch conductor and feed line is kept constant, equal to the feed line's width; variations in the input impedance at resonant frequency with respect to inset length will studied as a function of various parameters.

Assuming the patch antenna is divided into four regions, it can be modeled as a series of transmission lines loaded by radiating slots of different length **(Fig. 2)**. The **table** lists

Parameters of elements in the model

ELEMENT	WIDTH	LENGTH
TL1	W	$L - y_o$
SLOT A	h	W
TL2	$(W - 3w_f)/2$	y_o
SLOT B	h	$(W - 3w_f)/2$
TL3	$(W - 3w_f)/2$	y_o
SLOT C	h	$3w_f$

2W & 5W DC to 18GHz ATTENUATORS

from $29.95 ea. (1-49)

Rugged Stainless Steel Construction, High Repeatability, Miniature Size, Low Cost, and Off-The-Shelf Availability are some of the features that make Mini-Circuits "BW" family of precision fixed attenuators stand above the crowd! This extremely broad band DC to 18GHz series is available in 5 watt Type-N and 2&5 watt SMA coaxial designs, each containing 15 models with nominal attenuation values from 1 to 40dB. Built tough to handle 125 watts maximum peak power, these high performance attenuators exhibit excellent temperature stability, 1.15:1 VSWR typical, and cover a wealth of applications. So contact Mini-Circuits today, and capture this next generation of performance and value!

Mini-Circuits...we're redefining what VALUE is all about!

MODELS (Add Prefix BW-)

2W SMA	5W SMA	5W Type-N	Attenuation (dB)	
$29.95	$44.95	$54.95	Nominal	Accuracy•
S1W2	S1W5	N1W5	1	±0.40
S2W2	S2W5	N2W5	2	±0.40
S3W2	S3W5	N3W5	3	±0.40
S4W2	S4W5	N4W5	4	±0.40
S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	±0.60
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	±0.60
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	±0.60
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	±0.85

•At 25°C includes power and frequency variations up to 12.4GHz. Above 12.4GHz add 0.5dB typ. to accuracy.

DC-18GHz Adapters NOW AVAILABLE!

Type-N to SMA $22.95 ea. (qty. 1-49) SMA to SMA $4.95 ea. $5.95 ea. $8.95 ea.

For detailed adapter specs visit: ***www.minicircuits.com/adapter.html***

Mini-Circuits®

CIRCLE READER SERVICE CARD

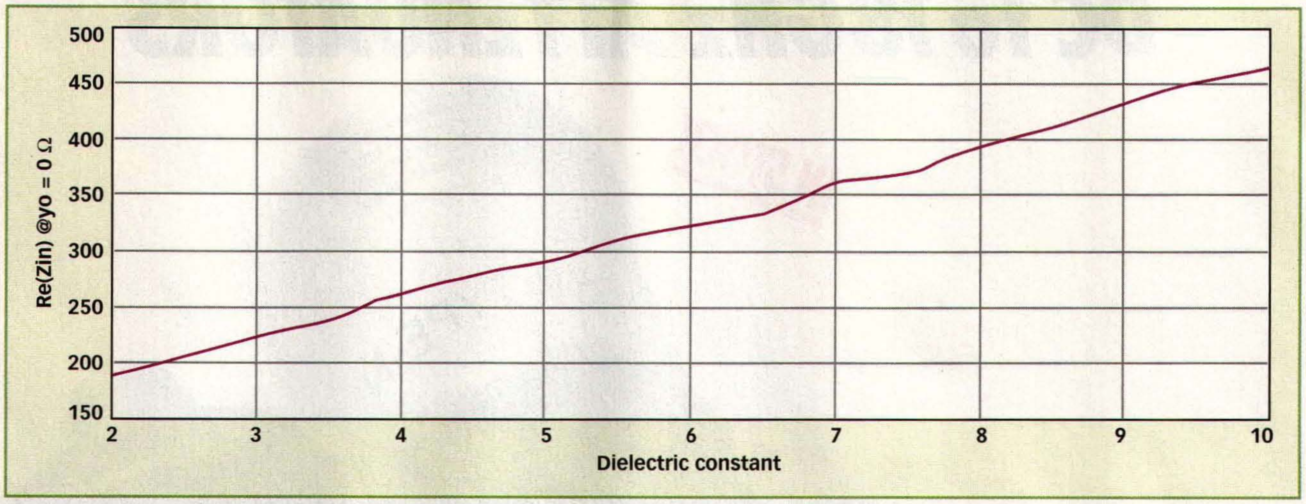
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE

YONI™ ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

ISO 9001 ISO 14001 CERTIFIED

331 Rev D

See our 244 page RF/IF Designer's Guide in EEM (Electronic Engineers Master)



4. This plot shows that a edge-fed rectangular patch antenna will have input resistance varying from about 150 to 450 Ω for values of dielectric constant from 2 to 10.

the parameters (width and length) of the three transmission lines as well as the width and lengths of the three radiating slots. Radiating slots A, B, and C can be modeled according to the guidelines presented in ref. 5.

Following the strategy outlined earlier, a patch antenna with the parameters $\epsilon_r = 2.42$, h = 0.127 cm, W = 5.94 cm, L = 4.04 cm, and y_0 = 0.99 cm was analyzed. **Figure 3** shows a comparison between the results obtained using the transmission-line-model method presented here and data obtained using a commercial computer-aided-engineering (CAE) electromagnetic (EM) simulator. Even though there is a shift in the resonant


POLARIS™ TOTAL RADIO™
Highly Integrated
Small Board Space
Low Cost
Minimal Bill of Materials
RFMD RF2722
RFMD RF3146
RFMD RF6001

$$y_o = 10^{-4}\left\{\begin{matrix}0.001699\varepsilon^7{}_r + 0.13761\varepsilon^6{}_r - 6.1783\varepsilon^5{}_r + 93.187\varepsilon^4{}_r - 682.69\varepsilon^3{}_r + \\ 2.561.9\varepsilon^2{}_r - 4043\varepsilon_r + 6697\end{matrix}\right\}\frac{L}{2}$$

$$(2 \le \varepsilon_r \le 10) \qquad (1)$$

frequency, the transmission-line model tracks the return loss profile predicted by the EM simulator very closely. The small shift in the resonant frequency can be attributed to a failure to consider the discontinuity between the inset feed line and the patch.

The transmission-line model was used to perform parametric studies of the patch for various values of ϵ_r ($2 \leq \epsilon_r \leq 10$). **Figure 4** shows that a rectangular microstrip patch antenna fed by a microstrip line at the edge ($y_0 = 0$) will have a higher input resistance varying from approximately 150 to 450 Ω for varying ϵ_r. Also, it was observed that the input impedance falls rapidly as the inset position is moved from the edge of the patch toward the center compared to the coaxially probe fed patch antennas. These parametric studies have been used to derive the curve-fit formula (Eq. 1) to find the exact inset length to achieve 50-Ω input impedance for commonly used thin dielectric substrates:

***The** transmission-line model tracks the return loss predicted by the EM simulator very closely.*

SEE EQ. 1 IN BOX ABOVE

The accuracy of this formula has been checked for a patch with $\epsilon_r = 5.0$, h = 0.127 cm, W = 4.1325 cm, L = 2.8106 cm, and y_0 = 0.9009 cm. To confirm the validity of the formula, the patch was analyzed using an EM simulator; **Fig. 5** offers a comparison between results generated by the transmission-line model and predictions from the EM simulation. Even though there is a one-percent shift in the resonant frequency between the two sets of data,

(Continued on page 108)

Designing Short High Q Resonators

Shrinking a transmission-line resonator's length can improve its quality factor while saving valuable printed-circuit-board real estate.

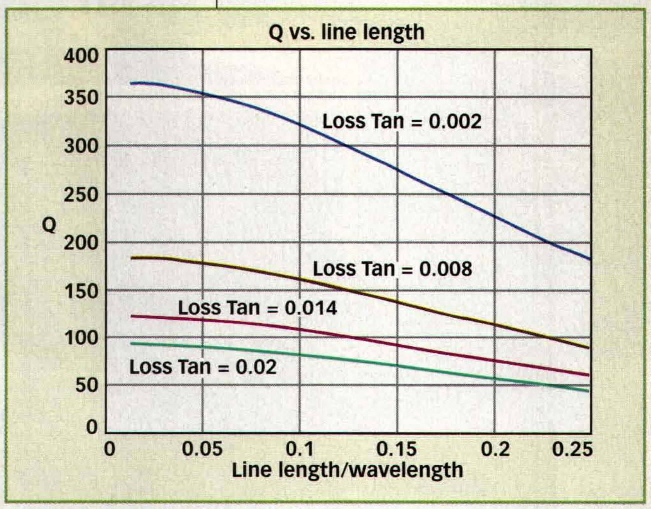
Resonators with high quality factors (Qs) are used throughout high-frequency circuits. For example, matching networks are most efficient when constructed with components having high unloaded Qs. By increasing the amount of stored energy to the loss of a circuit, it is possible to improve its unloaded Q. Fortunately, a low-cost commercial computer-aided-engineering (CAE) program can help design high Q transmission-line resonators that are electrically short (less than one-quarter wavelength).

DALE D. HENKES, ACS
President
Applied Computational Sciences, 1061 Dragt Pl., Escondido, CA 92029; (760) 612-6988, e-mail: LINC2@appliedmicrowave.com, Internet: www.appliedmicrowave.com.

In a multisection lowpass filter, the insertion loss is inversely proportional to the average unloaded component Q (Q_U).[1] For a single resonator, the insertion loss in dB approaches zero as the ratio of unloaded to loaded Q becomes infinitely large. For a parallel LC resonator, this implies that the individual component Q will need to be large compared to the loaded Q (terminated circuit Q) for low insertion loss.

A variety of oscillator performance parameters can benefit from a high-Q resonator, including phase noise and frequency drift (long-term frequency stability). It has been shown that the single-sideband (SSB) phase noise of a feedback oscillator is in part inversely related to the square of the loaded circuit Q.[2] Other factors, such as amplifier noise factor and signal power, affect overall phase noise in direct proportion only to their magnitudes. The exponential (second power) influence of the Q factor gives it a prominent impact on oscillator phase noise.

A circuit's Q can basically be defined as equal to two times the product of π and



1. The Q values for transmission-line sections with different loss tangents are plotted here as a function of line length.


INDOOR/OUTDOOR
Custom-made connectivity solutions for indoor and outdoor applications
■ SENCITY®ART ultra-broadband antenna with unique design for the wireless office
■ Full range of antennas for Picocell applications available
■ Surge Protection for Wireless Applications up to 5.8 GHz
HUBER+SUHNER
USA and Canada:
Toll free 1 866 HUBER SUHNER
(1-866-482-3778)
Fax: 1-847-397-2882
www.hubersuhnerinc.com
HUBER+SUHNER AG
Communications+Power Networ
9100 Herisau, Switzerland
Phone +41 (0)71 353 41 11
Fax +41 (0)71 353 47 51
www.hubersuhner.com
HUBER+SUHNER – Excellence in Connectivity Solutions

the ratio of the maximum energy stored to the energy dissipated per cycle. In an electrical circuit, energy is stored in the electric or magnetic fields associated with reactive circuit components and electrical energy is lost (to heat) whenever current flows through a resistance. From this basic definition, the way to improve Q is to increase the ratio of stored energy to losses in a circuit. Although how to achieve this may not always be apparent, a commercial software program that combines synthesis with simulation, the LINC2 program from Applied Computational Sciences (Escondido, CA), can simplify the task.

A section of transmission line shorted at one end will form a resonant circuit at the frequency represented by its quarter wavelength (90-deg. electrical length). Ports coupled into and out of the top side of the resonator form a bandpass circuit similar to a parallel-resonant resistive-inductive-capacitive (RLC) circuit. The Q of this full-length (quarter-wave) resonator can be found from:

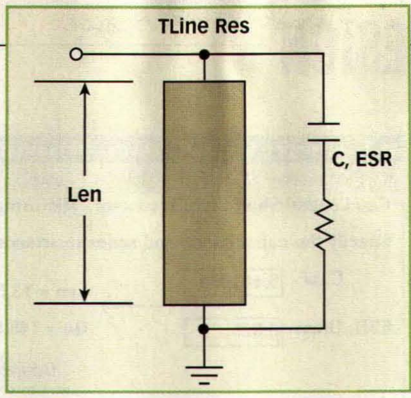
$$Q = 8.686\pi / (\alpha\lambda) \qquad (1)$$

where:

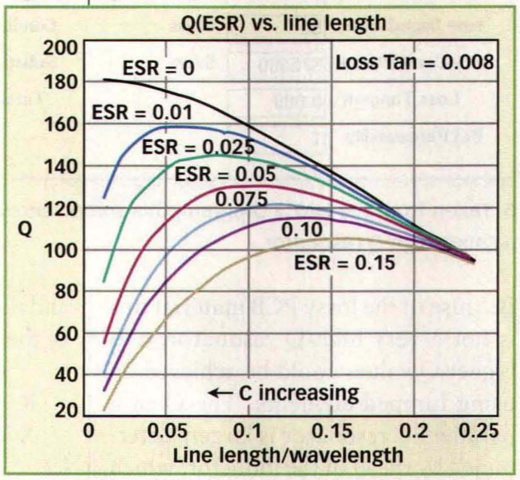
α = the line loss (dB/in.), and

λ = the wavelength (in.).

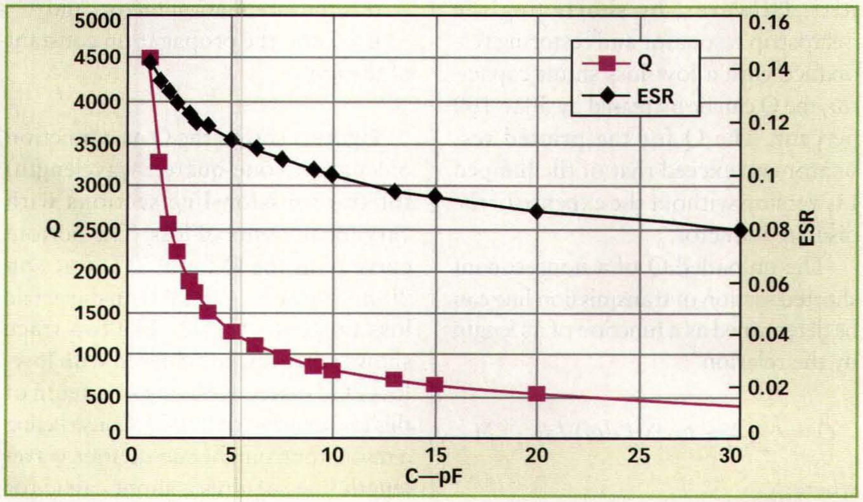
As an example, consider a resonator constructed on FR-4 printed-circuit-board (PCB) material with the following material properties at 1 GHz: relative dielectric constant, $\epsilon_r = 4.6$, dielectric height = 30 mil, 50-Ω trace width of 54.4 mil on 0.5-oz. copper, α = 0.094 dB/in., and λ = 6.35 in. Using these values in Eq. 1 gives Q = 27.3/0.094/6.35 = 45.7.



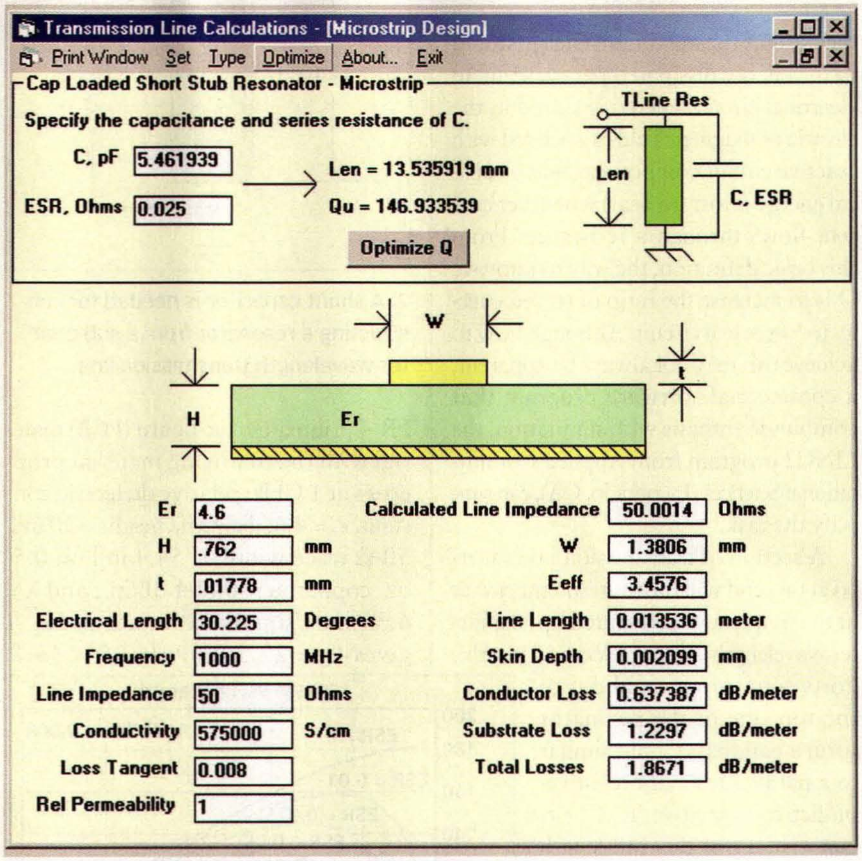
2. A shunt capacitor is needed for constructing a resonator from a sub-quarter-wavelength transmission line.



3. Resonator unloaded Q values are plotted here for different values of effective series resistance (ESR).



4. This plot shows changes in Q and ESR for a series of low-loss, high-frequency capacitors (C).



5. Taken from the LINC2 program, this screen shows the design process for creating a short, high-Q resonator.

Because of the lossy PCB material this is not a very high-Q resonator, and higher Q values could be achieved by using lumped elements. The Q of a parallel LC resonator is largely determined by the Q of the inductor, which can be as high as 60 or more at this frequency for a surface-mount 0603 size part. However, by shortening the microstrip resonator and restoring resonance with a low-loss shunt capacitor, the Q can be increased by 50 to 100 percent. The Q for the printed resonator can exceed that of the lumped LC version without the expense of the discrete inductor.

The unloaded Q of a nonresonant shorted section of transmission line can be determined as a function of its length by the relation[3]:

$$Q = \tfrac{1}{2}(X + \omega\, dX / d\omega) / R \quad (2)$$

where:

$\omega = 2\pi f$

and the real and imaginary components of the line impedance are:

$$R = Z_0 \sinh(2\alpha l)/[\cosh(2\alpha l) + \cos(2\beta l)]$$
$$X = Z_0 \sin(2\beta l)/[(\cosh(2\alpha l) + \cos(2\beta l))]$$

where:

α is the attenuation factor, and

$\beta = 2\pi/\lambda$, the propagation constant of the line.

Figure 1 shows the Q as a function of length (to one-quarter wavelength) for transmission-line sections with varying amounts of loss. The bottom curve plots the Q for a 50-Ω trace on 30-mil-thick FR-4 PCB with dielectric loss tangent of 0.02. The top trace shows what can be achieved with low-loss PCB material having one-tenth of this loss tangent (or 0.002). Constructing a resonator from the sub-quarter-wavelength line requires a shunt capacitor to restore resonance as shown in **Fig. 2.** The capacitor has loss that will add

SUPER FAST
VERY HIGH ISOLATION

SWITCHES

SPDT, DC-5GHz From $1.95* ea. (10,000) IN STOCK

Mini-Circuits wideband SPDT switches offer very high isolation up to 90dB at 1GHz, built-in TTL driver with blazing fast 10nsec switching speed, and the ability to withstand severe operating temperatures ranging from -40°C to +85°C. But that's not all! Reflective and absorptive models are available to suit your design requirements; M3SW's 3x3mm MCLP™ surface mount package with exposed metal bottom for excellent grounding and heat dissipation and ZASW's tough built coaxial design with SMA-F connectors. No matter which model you choose, you'll get strong performance and rugged reliability at a price that crushes the competition. So look no further. You'll find just the right switch for your commercial, industrial, or military application right here at Mini-Circuits!

Mini-Circuits...we're redefining what VALUE is all about!

SPECIFICATIONS (@ 1GHz)

Model	Freq. (GHz)	In-Out Isol. dB(typ)	Ins. Loss dB(typ)	1dB Comp. dBm(typ)	Price $ea. (Qty. 10)
• M3SW-2-50DR	DC-4.5	60	0.7	25	4.95 *
■ *M3SWA-2-50DR*	*DC-4.5*	*65*	*0.7*	*25*	*4.95 **
					(Qty. 1-9)
• ZASW-2-50DR	DC-5	90	1.7	20	89.95
■ *ZASWA-2-50DR*	*DC-5*	*90*	*1.7*	*20*	*89.95*

Supply voltage +5V, -5V. TTL control.
Switching time 10nsec (typ).
• Reflective ■ *Absorptive*

3x3mm
Mini-Circuits Low Profile (MCLP™)

Detailed Performance Data & Specs Online at: ***www.minicircuits.com/model***

Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE

YONI™ ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

ISO 9001 ISO 14001 *CERTIFIED*

379 Rev G

See our 244 page RF/IF Designer's Guide in EEM (Electronic Engineers Master)

$$Q_u = Q_l \times 10\exp(IL\_dB/20)/\left[10\exp(IL\_dB/20)-1\right] \quad (3)$$

$$Q_u = [\pi f Td] \times 10\exp(IL\_dB/20)/\left[10\exp(IL\_dB/20)-1\right] \quad (4)$$

to the total losses of the resonator and thus lower the Q. Figure 1 represents the unloaded Q of the line by itself, which would be equal to the Q of a resonator in the limiting case of an ideal (lossless) capacitor and transmission-line combination.

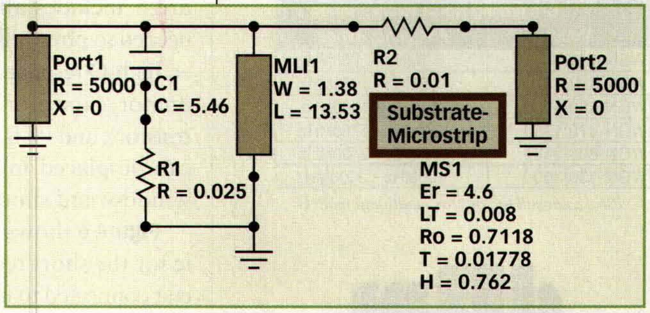
Figure 3 plots the unloaded Q of the resonator in Fig. 2 for various values of effective series resistance (ESR) for a capacitor resonating with the section of transmission line shown in Fig. 1 (with loss tangent of 0.008). For an ideal capacitor with ESR = 0 (top trace of Fig. 3), the resonator Q is the same as the transmission line Q in Fig. 1. Note that as the line length decreases the value of the capacitor increases to maintain resonance at the desired frequency (1 GHz in this case). As the resonator length is shortened (C increasing), the Q rises above the quarter-wavelength value of Q = $8.686\pi/(\alpha\lambda)$. However, for all resonating capacitors with ESR values greater than zero, the Q eventually falls again.

Figure 4 helps to show the effect of capacitor ESR on capacitor Q (and ultimately resonator Q). It plots the Q and ESR for a series of low-loss, high-frequency capacitors, with the Q of the capacitor equal to $1/[(ESR)\omega C]$, where C is capacitance. For a given frequency and constant ESR, the capacitor's Q would decrease inversely with C. Although this is not quite the case, the ESR decreases slowly enough with increasing C values that the effect is the same. Starting at a capacitance of 1 pF and a Q of several thousand (for data taken at 200 MHz), the Q drops rapidly with increasing capacitance.

Since the overall Q of the resonator in Fig. 2 is $Q_{resonator} = 1/[(1/Q_c)+(1/Q_t)]$, Fig. 4 explains the eventual decline in the resonator Q for very short line lengths and large capacitor values. The falling capacitor Q (Q_c) finally overtakes the increasing transmission-line Q (Q_t). However, before it does, there is an optimum line length where maximum resonator Q is achieved.

Equation 2 does a fair job of predicting the transmission line Q up to the vicinity of self-resonance at one-quarter wavelength. However, as the resonator length exceeds 90 percent of a quarter wavelength, Eq. 2 begins to lose accuracy. Fortunately, the LINC2 program uses a proprietary algorithm to accurately calculate the Q of a parallel transmission-line/capacitor resonator through all ranges of line length up to and including one-quarter wavelength. In performing the calculations, LINC2 automatically takes into account the PCB material and the type of transmission-line (microstrip or stripline) structure **(Fig. 5)**.

In using this program, the first step in the design process requires entering information about the PCB material and the metal (trace) parameters. From this information, the physical dimensions of the metal strip are calculated and displayed. In addition, the software computes other physical properties, including the line loss and unloaded resonator Q for any given type of capacitor. Upon entering the capacitance and ESR for the resonator capacitor, the



6. In order to create simulated measurement results, the input and output of the short resonator is connected to high-impedance measurement ports.

strip length and Q of the resonator are displayed.

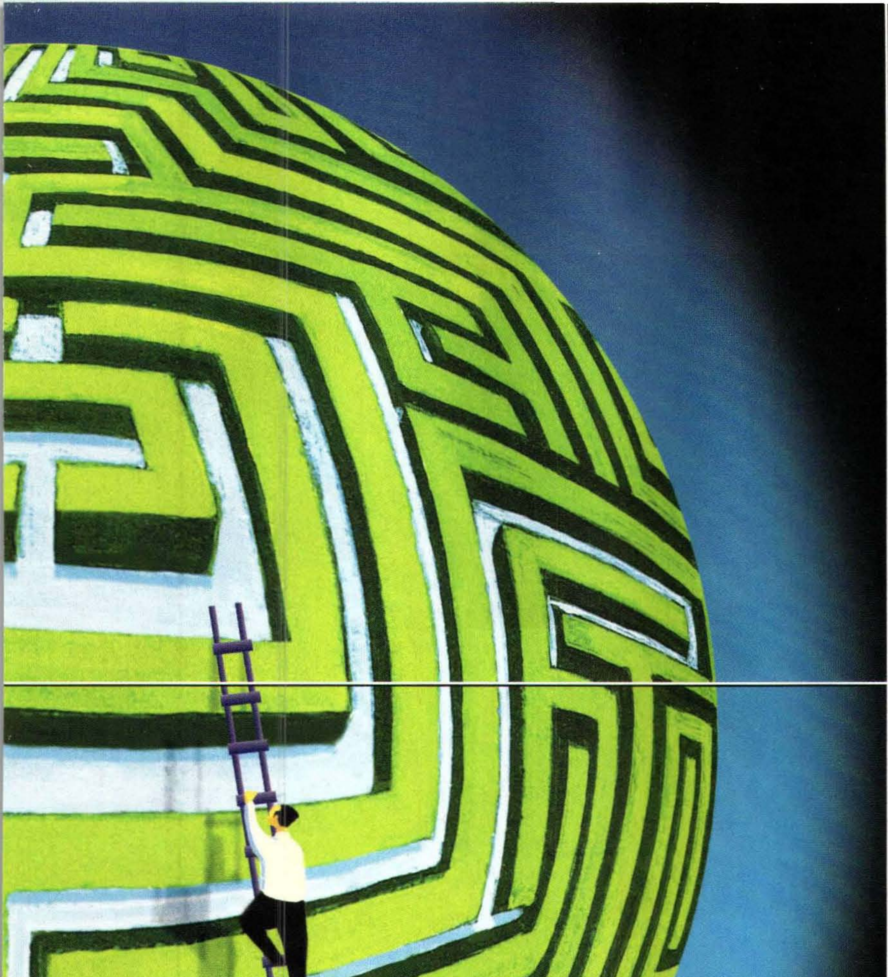
An important feature of the program is its ability to optimize the resonator Q by finding the optimum capacitor value and line length for maximum Q. Since all calculations are based on the specified metal and substrate material, different PCB materials can be quickly analyzed for their ability to support a resonator design for a desired Q factor.

A design example will involve determining the unloaded Q for a full-length (quarter-wavelength) resonator on 50-Ω microstrip using the PCB material of Fig. 5, as well as the maximum unloaded Q for a (shorter) 50-Ω microstrip resonator on the same PCB material. The line length and the value of a resonating capacitor (one capacitor with ESR of 0.025) must also be calculated for that maximum Q value. In addition, it will be necessary to compute the percent improvement in Q for the shorter resonator compared to the full-length resonator. Finally, the design example will involve verifying the Q of the shorter resonator through a computer simulation.

To complete this design example with the LINC2 program, the Q for a quarter-wavelength resonator can be obtained by entering a very small value for C (such as 0.001 pF). This effectively removes the loading capacitor and lets the resonator go to full length. After entering the material specifications (from Fig. 5) and 0.001 for the value of C, the program reports an unloaded Q of 92. The Q can also be calculated manually from Eq. 1. Substituting the appropriate values yields $Q_u = 27.3/1.867/0.161 = 91$, which is close to the program-computed value.

Entering 0.025 for the capacitor's ESR and clicking the "Optimize Q" button in LINC2 yields a $Q_{u,max}$ of 146.93, a line length of 13.536 mm (note that the resonator strip has been shortened to 30.225 deg.), and C of 5.46 pF (see Fig. 5). The quarter-wavelength resonator has a Q = 92 while the short resonator produced a Q = 146.93. The percentage improvement in Q is 100(146.93 – 92)/92 = 59.7 percent. Figure 5 includes all of the information needed to physically construct the shorter, high-Q resonator. The microstrip resonator, capacitor (with ESR modeling resistor), and PCB material specification can be placed in a LINC2 schematic window and simulated.

Figure 6 shows the LINC2 schematic for the short resonator with the circuit connected to input and output measurement ports. High-impedance (5000 Ω) measurement ports were used to lightly load the resonator, allowing for



enough insertion loss to aid the calculation of unloaded Q as a function of loaded Q and insertion loss (Eq. 3).

From the simulation, the unloaded Q (Q_u) can be calculated from the simulated loaded Q (Q_l) by:

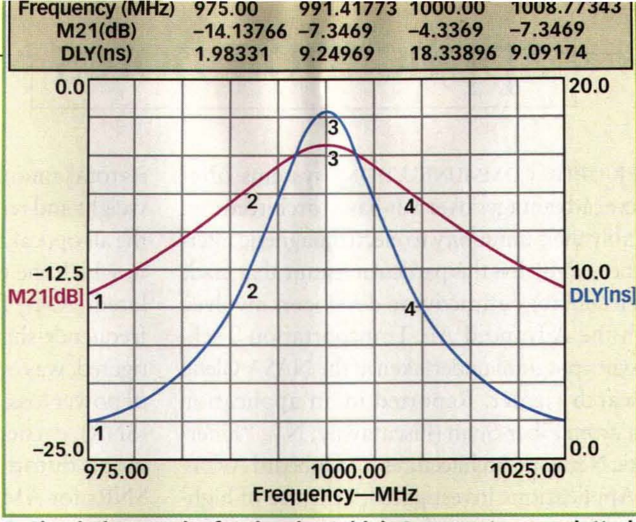
SEE EQ. 3 On P. 81

where:

IL_dB = the insertion loss (in dB) at the center frequency, F_c, and

$Q_l = F_c/(BW\_3dB)$.

Figure 7 offers simulation results for the short resonator, with markers placed at the upper and lower 3-dB points. The plot indicates a 3-dB bandwidth (BW_3dB) of 1008.77343 – 991.41773 = 17.3557. The insertion loss (IL_dB) is 4.3369 dB.



7. Simulation results for the short, high-Q resonator are plotted around a center frequency of 1 GHz.

The simulated loaded Q is:

$Q_l = F_c/(BW\_3dB) = 1000/17.3557 = 57.62.$

The unloaded Q (Q_u of the resonator can now be obtained from Eq. 3 as:

$Q_u = 57.62 [10exp(4.3369/20)]/[10exp(4.3369/20) - 1] = 146.6.$

This agrees very closely with the unloaded Q reported by the synthesis program (Q_u = 146.9 in Fig. 5). This verifies (through simulation) the design and physical construction details proposed by synthesis.

The loaded Q can also be calculated from the group delay according to the relation:

$$Q_l = \omega T_d/2$$

where:

$\omega = 2\pi f$ and

T_d = the time delay.

Equation 3 can now be rewritten as:

SEE EQ. 4 ON P. 81

The delay reported in the simula-

(Continued on page 109)

RESONATOR

Investigate Fiber-Optics For Onboard Avionics

FIBER-OPTIC COMMUNICATIONS systems offer several advantages over RF-based architectures, notably their immunity to electromagnetic interference (EMI). It is this particular feature that made this technology attractive to developers involved with the Advanced Air Transportation Technologies program undertaken at the NASA Glenn Research Center. Reported in an application note from Fiber-Span (Piscataway, NJ), "Fiber-Optic Network Architectures for Onboard Avionics Applications Investigated," the use of high-speed fiber-optic technology was used for high-bandwidth digital data communications between an aircraft and the outside world.

Other concerns in developing the system included safety and reliability, low-power consumption, sufficiently low weight for avionics use, and relatively low cost. The application note details several design approaches to this communications challenge, including a hybrid RF/optical system with RF multiplexers and demultiplexers, optical transmitters, and optical receivers, and an all-optical solution based on wavelength division multiplexing (WDM). The hybrid approach can be installed with fewer optical fibers, although its total amount of hadware tends to have more weight and require higher operating power than the all-optical approach. The all-optical approach, in which the transmission of amplitude-modulated (AM), frequency-modulated (FM), and frequency-shift-keying (FSK) signals were investigated, was evaluated by making measurements of power loss, signal delay, signal-to-noise ratio (SNR), carrier-to-noise ratio (CNR), total harmonic distortion, and bit-error rate (BER). The SNRs for AM and FM transmissions at optical wavelengths of 1310 and 1550 nm were measurred at approximately 55 and 40 dB, respectively. The measurements suggest good analog signal transmission over WDM fiber-optic links, easily exceeding the 30-dB minimum SNR needed for acceptable AM and FM reception. The CNRs for the 1310 and 1550 nm wavelengths were 65 and 52 dB, respectively, exceeding the minimum requirement of 40 dB.

Fiber-Span, 1 Possumtown Rd., Second Floor, Piscataway, NJ 08854; (732) 564-9000, FAX: (732) 564-1990, e-mail: henry@fiber-span.com, Internet: www.fiber-span.com.

The application note details several design approaches to this communications challenge, including a hybrid RF/optical system and an all-optical solution based on WDM.

Solving Circuit-Board Housing Cavity Resonances

CAVITY-RESONANCE PROBLEMS can plague even the most carefully designed microwave circuits. Since high-frequency circuits are often tuned without considering the effects of an enclosure, the addition of a protective housing can give rise to resonances with adverse effects on circuit-board performance. For example, unwanted resonances caused by the conductive walls of an enclosure can alter the input and output impedances of a microwave circuit, derailing any efforts to precisely tune those ports for a good 50-Ω match.

Although the problem of cavity resonances is fundamental to high-frequency design, an application note from Emerson and Cuming (Randolph, MA), "Circuit Board Housing Cavity Resonances," explains how adding microwave absorbing material to a cavity has proven to be a quick and inexpensive method for eliminating cavity resonances. As the note details, basic field theory states that the insertion of a high-permeability/permittivity material in a cavity will cause the field distribution to shift such that the vast majority of the energy is oscillating within the material. If the material is also lossy, then the energy will also be attenuated.

The note, which is available for free download from the company's website, presents guidelines for choosing a cavity resonance absorber material. For example, it reviews materials types (such as elastomers and epoxies), material thicknesses (the trade-off between achieving resonance suppression against the cost of thicker materials), the method of adhesion, and when it is important to consider outgassing effects (such as the deleterious effects of hydrogen outgassing in a circuit containing gallium-arsendide (GaAs) components. The easy-to-read three-page application note is an excellent introduction to packaging resonance problems and the types of materials that can be used to solve those problems.

Emerson & Cuming Microwave Products, 28 York Ave., Randolph, MA 02368; (781) 961-9600, FAX: (781) 961-2845, e-mail: sales@eccosorb.com, Internet: www.eccosorb.com.

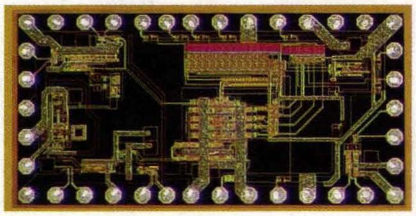
cover story

SiGe Fires Single-Chip Fractional-N Synthesizer

A high-frequency SiGe process, a carefully designed sigma-delta modulator, and high-frequency monolithic VCOs combine for a synthesizer capable of operating to 30 GHz.

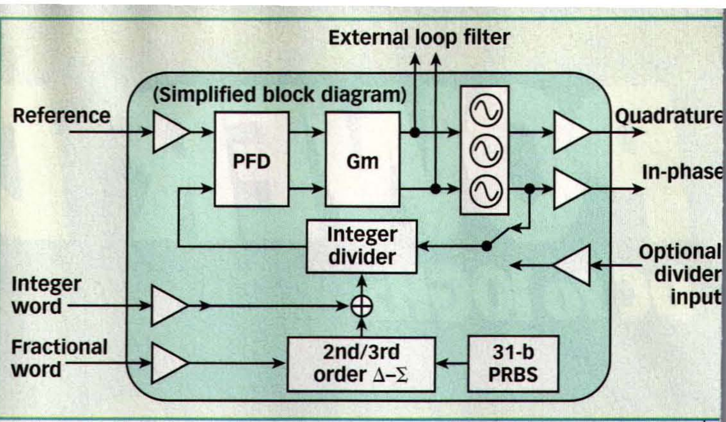
JACK BROWNE
Publisher/Editor

Silicon-germanium (SiGe) semiconductor technology has long held the promise of high-frequency operation with high levels of integration. The process technology made headlines in the early 1990s with claims of device transition frequencies that could surpass expensive gallium-arsenide (GaAs) technology while using standard silicon wafers. While the technology is now making its way into a variety of integrated circuits (ICs), mainly for cellular handsets and wireless-local-area-network (WLAN) cards, its integration potential has been largely untapped. A single-chip fractional-N SiGe synthesizer from Centellax (Santa Rosa, CA), however, offers a glimpse of what this technology can achieve, using multiple varactor-tuned voltage oscillators to cover frequencies between 20 and 30 GHz and a total of more than 10,000 transistors on chip.



1. The high-frequency fractional-N synthesizer leverages a high-speed SiGe process and straightforward CMOS technology to integrate analog and digital circuitry on a single chip.

The company, launched in February 2002, was founded by some of the leading design engineers in the high-frequency industry: Dr. Julio Perdomo, Jerry Orr, Christian Bourde (all formerly of Agilent Technologies), and German Gutierrez, with a background that includes stints at



2. This block diagram shows the essential functional parts of the SiGe fractional-N frequency synthesizer.

Broadcom and Silicon Wave. The company has already established a reputation for innovative use of SiGe heterojunction-bipolar-transistor technology with a series of extremely broadband amplifier (nominally for optical communications networks) ICs and modules, signal-processing modules, and switch/attenuator ICs through 50 GHz. For example, the UAXX65XX family of monolithic-microwave-integrated-circuit (MMIC) amplifier ICs cover a bandwidth approaching 65 GHz, with frequency range from 0.04 to 65 GHz.

The latest development from Centellax is a fractional-N frequency synthesizer **(Fig. 1)** that takes advantage of the excellent high-frequency performance of SiGe as well as the potential for integration when using silicon CMOS processing. The fractional-N frequency synthesizer IC contains the entire phase-locked-loop (PLL) along with the digital fractional dithering functions **(Fig. 2)**. The synthesizer features in-phase (I) and quadrature (Q) output ports and generates signals over the ranges of 10 to 15 GHz and 20 to 30 GHz. Its integration of VCO, synthesizer, and digital signal processing on a single chip offers a significant savings in size, cost, and power consumption compared to existing solutions for a wide range of broadband applications in commercial, industrial, and military systems.

A fractional-N synthesizer differs from a traditional integer-N in which the division ratio, N, is a fixed integer, forcing a trade-off between loop bandwidth (and tuning speed) and frequency step size. In a fractional-N synthesizer, the divide ratio is dynamically varied or dithered to achieve intermediate division ratios. In the Centellax device, dithering is accomplished by means of an all-digital delta-sigma modulator, allowing fine frequency resolution but with wide loop bandwidths. Although dithering the division ratio can introduce quantization noise, careful design of the modulator can achieve a similar lowpass transfer function as the reference source, in effect suppressing higher-frequency noise. By using a high-speed SiGe HBT process, Centellax can fabricate wideband monolithic voltage-controlled oscillators (VCOs) capable of fundamental frequencies of 30 GHz and higher as part of the fractional-N frequency synthesizer design.

Traditionally, HBT devices have been fabricated on GaAs or InP substrates, requiring complex and expensive process technologies. One of the benefits of SiGe HBT devices is that they can be fabricated with conventional silicon CMOS technology with only a few additional process steps. There are two heterojunctions in SiGe HBTs, one at the emitter-base junction and the other at the base-collector junction. SiGe technology allows cutoff frequencies of 300 GHz and more for small-geometry HBT devices, supported by all the benefits of traditional silicon CMOS integration of additional analog and digital structures. SiGe also features low 1/f device noise, high levels of analog and digital device integration, low materials costs, and low power consumption compared to other high-frequency semiconductor materials, such as InP and GaAs.

The new synthesizer features an integrated CMOS delta-sigma controller with optional external delta-sigma interface. The IC can generate fundamental frequencies to 30 GHz with step sizes as small as 25 kHz. It achieves typical output power of +5 dBm from its driver amplifier and includes divide-by-two outputs for half-frequency applications. The sigma-delta-modulator-based division-dithering approach minimizes phase noise (about 10 dB worse than the reference or typically –85 dBc/Hz offset 10 kHz from the carrier) while providing frequency-switching speeds (about 100 ns) associated with wide loop bandwidths.

The highly integrated Centellax fractional-N synthesizer IC requires minimal external components (external resistors and capacitors for the loop filter). Depending on these external circuit elements, the loop bandwidth can be extended to the tens of megahertz range to accommodate reference frequencies to 600 MHz while achieving aggressive suppression of VCO noise over wide bandwidths and also maintaining fast frequency switching speeds. The wide loop bandwidth also supports modern modulation formats, including wideband frequency modulation (FM) and frequency-shift-keying (FSK) modulation.

The fractional-N IC includes a bank of varactor-tuned VCOs, each one covering a subset of the desired frequency range. This allows a broad tuning range while maintaining low phase noise. In addition to the high frequency coverage, the VCO output can be selected through an on-chip divide-by-2 prescaler for half-rate applications. Quadrature output signals are also available, or can be disabled to conserve power.

The IC's fully programmable integer divider features division modulus ratios from 4 to 255. The divide ratios are dynamically switched according to the CMOS fractional dithering sequence. Dithering can be initiated with the on-chip selectable second- or third-order delta-sigma modulator, with optional least-significant-bit (LSB) dithering from a 31-b pseudorandom-bit-sequence (PRBS) generator, or externally by deselecting the on-chip modulator. The flexible fractional-N synthesizer IC also allows the use access to the divider input port, to disable the on-chip bank of VCOs and use an external VCO. **Centellax, 451 Aviation Blvd., Suite 101, Santa Rosa, CA 95403-1069; (866) 522-6888, (707) 568-5900 ext. 46, FAX: (707) 568-7647, Internet: www.centellax.com.**

Read/Write RFID Chips Boast Large Memory

These compact RFID chips offer on-chip electroformed antennas, generous memory and long data retention times for a wide range of identification applications.

JACK BROWNE
Publisher/Editor

Radio-frequency identification (RFID) technology represents an invaluable tool for a wide range of industries, including in industrial, medical, and military markets. A company often associated with analog and digital recording technologies, Maxell Corp. of America (Fair Lawn, NJ), has applied its expertise in data portability to the development of a large-memory-capacity RFID chip, the ME-Y2000 Series. The new RFID chips offer as much as 32 times more memory than the company's earlier RFID solutions, in a package measuring only 2.5 × 2.5 mm complete with on-chip antenna.

The ME-Y2000 series chips **(see figure)** are available with memory sizes of 1, 2, and 4 kB, compared to a mere 128 B of memory in the earlier ME-Y1000 product line. Designed for an operating distance of 3 mm at 13.56 MHz, the new RFID chips can be used for more than 100,000 write cycles, at a data-transfer rate of 212 kb/s. A 32-b key code is used as part of the write process. The chips can retain data for at least 10 years, making them well suited for high-performance industrial, medical, and military applications. These reliable RFID chips are already been used in security identification cards, for counterfeit prevention, for scientific applications regarding management of chemical reagents, and for medical research for test-tube identification.

The ME-Y2000 Series RFID chips provide as much as 4 kB memory size and an on-chip antenna for identification and security applications at 13.56 MHz.

In addition to the amount of memory, an impressive part of the technology is the coil-on-chip antenna that provides the air interface between the ME-Y2000's circuitry and a reader/writer platform. Fabricated by means of a precision electroforming process which adds the metal antenna patterns to the silicon chip, the antenna features a coil with 14-μm width and 4-μm gap between lines.

Maxell (the name stems from a shortening of "maximum capacity dry cell," a description of the company's dry cell batteries) also offers a compact read/write platform for use with the ME-Y1000 and ME-Y2000 chips. The platform, which is contained on a printed-circuit board (PCB) measuring only 50 × 60 mm, supports a variety of host interfaces, including USB, UART, and RS-232C standards. For more information on the RFID chips, or the company's capabilities in high-speed optical-communications technology, visit the website at www.maxell.com. **Maxell Corp. of America, 22-08 Route 208, Fair Lawn, NJ 07410; (201) 703-8075, FAX: (201) 796-8790, e-mail: afujiwara@maxell.com, Internet: www.maxell.com.**

300MHz-12GHz

LTCC MIXERS

from $3.95 IN STOCK ea. (Qty. 1000)

For Commercial, Military, and Industrial Use, Mini-Circuits proudly introduces the MCA1 series of Low Temperature Co-fired Ceramic (LTCC) frequency mixers. Highly reliable, only 0.080" in height, and tough as nails, these patent pending mixers have all circuitry hermetically imbedded inside the ceramic making them temperature stable and impervious to most environmental conditions. The process also gives you high performance repeatability and very low cost. There's a variety of broadband models and LO power levels to choose from, so you can use these mixers in a multitude of designs and applications. And MCA1 mixers are ideal for the COTS program! Just check all the specs on our web site. Then, choose the model that best fits your needs. Our team is ready to handle your requirements with quick off-the-shelf shipments, custom designs, and fast turn-around/high volume production.

Mini-Circuits...we're redefining what VALUE is all about!

New Blue Cell™ LTCC 164 Page Handbook...FREE!

Model	LO Level (dBm)	Freq. Range (MHz)	Conv. Loss (dB)	LO-RF Isol. (dB)	Price $ ea. (Qty. 10)
MCA1-85L	4	2800-8500	6.0	35	9.45
MCA1-12GL	4	38800-12000	6.5	38	11.95
MCA1-24	7	300-2400	6.1	40	5.95
MCA1-42	7	1000-4200	6.1	35	6.95
MCA1-60	7	1600-6000	6.2	30	7.95
MCA1-85	7	2800-8500	5.6	38	8.95
MCA1-12G	7	3800-12000	6.2	38	10.95
MCA1-24LH	10	300-2400	6.5	40	6.45
MCA1-42LH	10	1000-4200	6.0	38	7.45
MCA1-60LH	10	1700-6000	6.3	30	8.45
MCA1-80LH	10	2800-8000	5.9	35	9.95
MCA1-24MH	13	300-2400	6.1	40	6.95
MCA1-42MH	13	1000-4200	6.2	35	7.95
MCA1-60MH	13	1600-6000	6.4	27	8.95
MCA1-80MH	13	2800-8000	5.7	27	10.95
MCA1-80H	17	2800-8000	6.3	34	11.95

Dimensions: (L) 0.30" x (W) 0.250" x (H) 0.080"

Detailed Performance Data & Specs Online at: **www.minicircuits.com/mixer2.html**

Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE

YONI™ ***The Design Engineers Search Engine*** *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

ISO 9001 ISO 14001 CERTIFIED

385 Rev E

See our 244 page RF/IF Designer's Guide in EEM (Electronic Engineers Master)

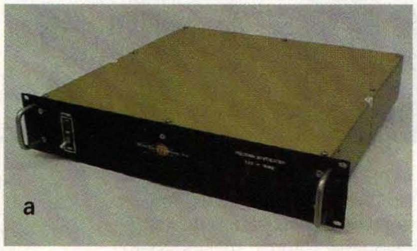
High-Speed Synthesizer Spans 2.25 To 18 GHz

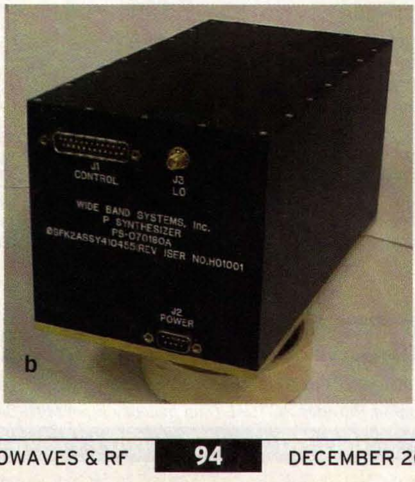
This wideband, low-phase-noise frequency synthesizer provides 3-μs frequency tuning speed over an instantaneous bandwidth of 2.25 to 18.0 GHz.

WILLIAM SULLIVAN
President
Wide Band Systems, Inc., 389 Franklin Ave., P.O. Box 289, Rockaway, NJ 07866; (973) 586-6500, FAX: (973) 627-9190, e-mail: Marketing@widebandsystems.com, Internet: www.widebandsystems.com.

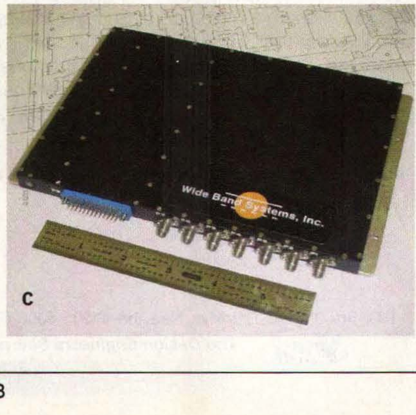
Sometimes specifiers become suppliers, especially when trying to meet demanding requirements. Such is the case with the Receiver Systems Division of Wide Band Systems (Rockaway, NJ). Often associated with military receiver components, and a long-time user of frequency synthesizers, the company has turned its attention to designing and supplying broadband, high-speed synthesizers for a variety of applications, including in test equipment, simulator systems, and as local oscillators (LOs) in advanced receiver systems. The first model operates from 2.25 to 18.0 GHz with 3-μs frequency switching speed and only 22 W DC power consumption, in a package with volume of only 334.3cm^3 (20.4 in.^{3}).

This fast-switching synthesizer (typically 1000 times faster than similar devices) provides a clean RF output spectrum with an absolute accuracy better than 10 kHz. Based on wideband frequency locking of a voltage-controlled oscillator (VCO) to a stable clock reference source, the patent-pending design represents


a



b

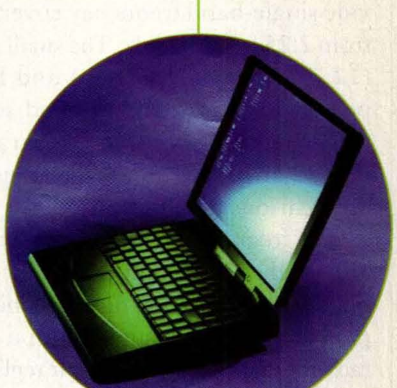


c

1. The wideband frequency synthesizers are available in three configurations: standard rack-mount form (a), replacement module (b), and a compact package that can be readily integrated into larger systems (c).

TriQuint Transforms Wireless Data...

Wireless data is transforming the world, and TriQuint makes it happen. Our GaAs PAs, LNAs, and switches, plus our Sawtek line of RF and IF WLAN filters, enable laptop and desktop computers to go wireless. TriQuint offers a full portfolio of active and passive components today that facilitate the high data rates and extended battery life that tomorrow's wireless devices will demand. Let TriQuint enhance your Bluetooth and wireless data competitive edge with our complete line of high-performance, cost-effective RF components.



POWER AMPLIFIERS

Package Type	Package Size	Part Number	Comments
TSSOP-10	3.0x5.0mm	CGB240B	22 dBm, 802.11 b
MLF-12	3.0x3.0mm	TQP2420B	23 dBm, 802.11 b
MLF-12	3.0x3.0mm	TQP2420G	19 dBm, 802.11 b/g
MLF-12	3.0x3.0mm	TQP2421BG	21 dBm, 802.11 b/g

SWITCHES

Package Type	Package Size	Part Number	Comments
SOT363	2.0x2.0mm	CSH210R	802.11 b, SPDT
SLIM-7	2.0x1.3mm	TQS5200	Dual-band, SPDT
MLF-12	3.0x3.0mm	TQS5201	802.11 b/g, DPDT
MLF-12	3.0x3.0mm	TQS5202	Dual-band, DPDT

LNAs

Package Type	Package Size	Part Number	Comments
SLIM-7	2.0x1.3mm	TQL5000	802.11 a, LNA

FILTERS

Frequency (MHz)	Bandwidth (MHz)	Package Size	Part Number
280.0	17.0	5.0x5.0mm	855975
374.0	17.0	5.0x5.0mm	855898
374.0	17.0	3.8x3.8mm	856187
374.0	17.0	3.8x3.8mm	856278
465.0	17.0	5.0x5.0mm	855991
549.5	10.0	7.0x5.5mm	855959
570.0	17.0	7.0x5.5mm	855869
770.0	17.0	5.0x5.0mm	855942
810.0	17.0	3.0x3.0mm	855896
1150.0	16.0	3.0x3.0mm	856256
1290.0	18.0	2.0x2.5mm	856366
2441.75	83.5	3.0x3.0mm	855916
2441.75	83.5	2.0x2.0mm	856166
2441.75	83.5	1.5x2.0mm	856306

TriQuint SEMICONDUCTOR

www.triquint.com
Phone: (503) 615-9000
Fax: (503) 615-8900
E-mail: info-sales@tqs.com

Solutions for Wireless and Broadband Communications

a new class of microwave synthesizer. In the design, a pair of suboctave VCOs are frequency doubled and then frequency doubled again to provide single-band frequency coverage from 2.25 to 18.0 GHz. The small size (12.7 × 195 × 135 mm) and low power consumption, coupled with the switching speed and accuracy, make it attractive for a wide range of applications **(see table)**.

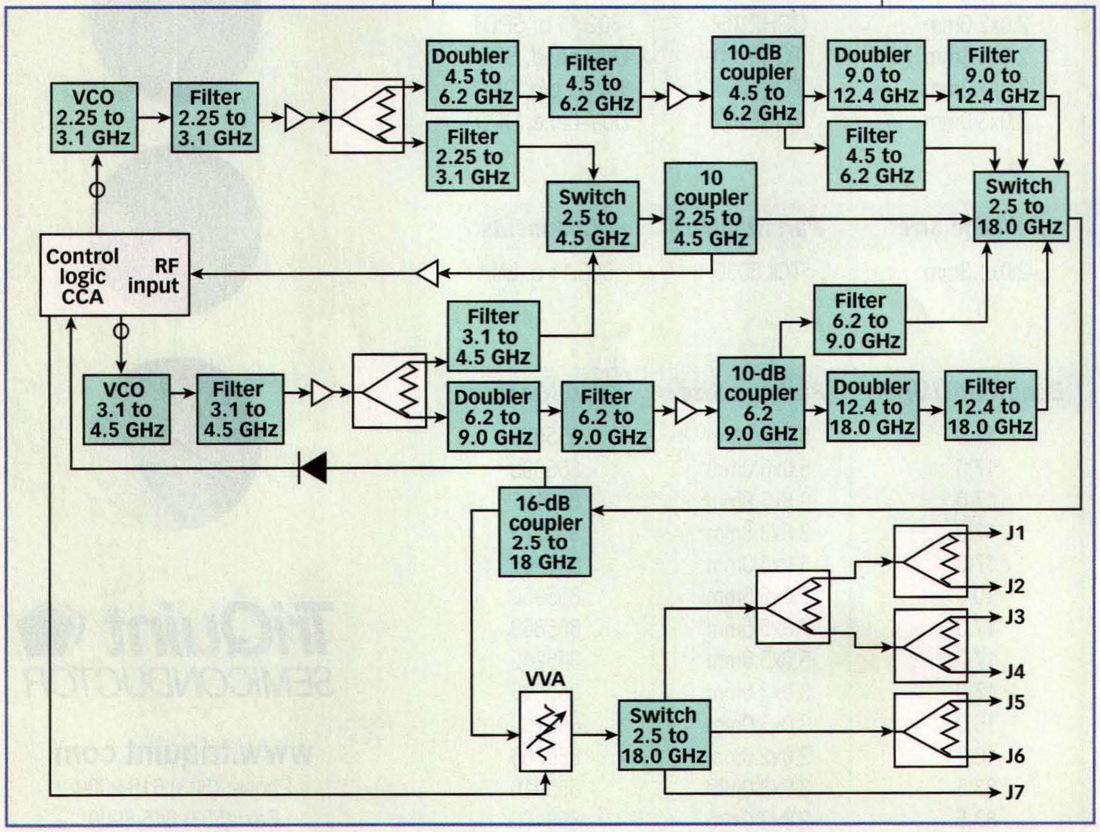
The frequency synthesizer is available in three different physical configurations **(Fig. 1)**, all of which incorporate a basic circuit design: a 2U rack-mount chassis, a modular replacement synthesizer, and an integrated package. All three configurations share the same circuits **(Fig. 2)**. The 2U rack chassis was configured to meet a specific installation requirement; the replacement synthesizer package was designed to replace an earlier phase-lock synthesizer design; and the integrated synthesizer configuration is a component of an airborne radar-warning-receiver (RWR) system.

The synthesizers at a glance

RF output range	2.25 to 18.0 GHz
Frequency resolution	1 MHz (optional to 3.9 kHz)
Output frequency accuracy	10 kHz
Harmonic/spurious outputs	-60 dBc
Phase noise	
Offset 10 kHz from a 2674.5-MHz carrier	-86 dBc/Hz
Offset 10 kHz from a 3801.0-MHz carrier	-76 dBc/Hz
Offset 10 kHz from a 15204.0-MHz carrier	-65 dBc/Hz
Offset 1 MHz from a 2674.5-MHz carrier	-96 dBc/Hz
Offset 1 MHz from a 3801.0-MHz carrier	-95 dBc/Hz
Offset 1 MHz from a 15204.0-MHz carrier	-82 dBc/Hz
Tuning time	3 μs (typical) 7 μs (maximum)
DC power consumption	25 W
Physical configurations	
Rack-mount (2U) chassis	RETMA 2U rack chassis
Replacement style chassis	120.99 × 222.25 × 120.65 mm
Integrated chassis	135 × 195 × 12.7 mm (w/o cooling fins)

Frequency accuracy is better than 10 kHz for all three synthesizer configurations **(Fig. 3)**, while standard frequency resolution is 1 MHz; resolution as fine as 3.9 kHz is available. Harmonic and spurious content is controlled to –60 dBc, while phase noise is at least –86 dBc/Hz offset 10 kHz from a 2674.5-MHz carrier **(Fig. 4)** and better than –76 dBc/Hz at the same offset from a 3801-MHz carrier **(Fig. 5)**. The phase noise improves to better than –95 dBc/Hz offset 1 MHz from either carrier frequency.

With respect to tuning time, the synthesizer blanks the RF output during an output frequency transition. When a frequency synthesizer is employed as an LO in a narrow-bandwidth intermediate-frequency (IF) tuner, failure to blank the LO output when changing frequency may produce an uncontrolled spurious frequency in the tuner's IF filter. The tuner would then have to wait

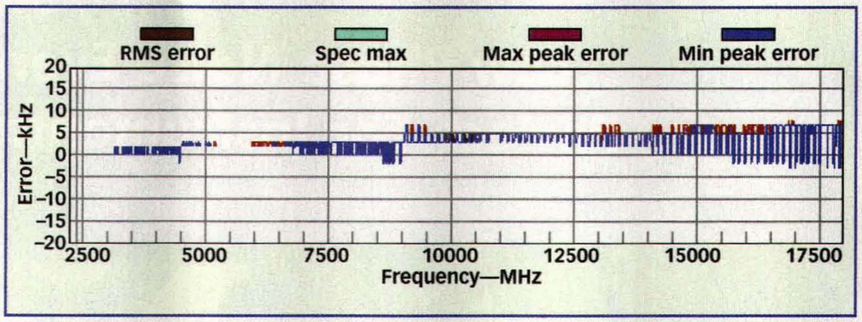


2. This novel synthesizer architecture combines traditional RF signal-processing components with a FPGA-based digital circuitry for fast switching with low noise.

until this spurious filter response dies out, wasting valuable receiver time. Since the synthesizer operates by comparing the current VCO frequency to an input-selected RF signal, digital processing automatically blanks the synthesizer RF output as soon as a strobe is received loading new frequency data. Blanking is released when the processor determines that the synthesizer output frequency is within a preset margin (such as 1 MHz) of the programmed frequency. If a fault should occur in the synthesizer (where the automatic measurement function does not detect the output frequency to be within this preset margin), the synthesizer will remain blanked and an output error flag will be set.

Since the processing and control of the VCO is accomplished digitally using high-speed field-programmable gate arrays (FPGAs), the synthesizer is capable of not only providing the selected output RF, but can also provide output of programmed patterns of output frequencies. These patterns can be a sequence of frequencies, a sequence of RF pulses, a sequence of amplitudes, or any combination of frequency, timing, and amplitude sequences desired.

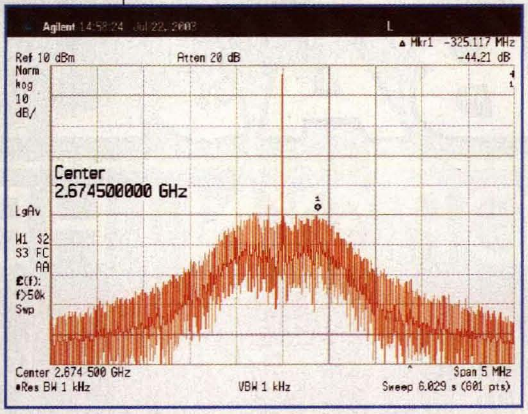
The circuit topology of Fig. 1 was adopted with revised RF and digital circuitry to improve the VCO output spectrum, including suppression of harmonics and spurious content, while simultaneously improving the set-on timing. Two suboctave VCOs were used in parallel, avoiding the problem of VCO harmonics and reducing the tuning sensitivity required of each VCO. The selected baseband VCO output is provided to a digital implementation of an ambiguous frequency correlator, measuring the rate of change of phase of the selected VCO output and comparing this measurement to that of the desired RF output frequency. The difference between the measured and predicted rate of change of phase is used to correct the VCO frequency. Switches then select the desired multiple of the corrected VCO frequency. The output RF power level is detected and used to control the voltage variable attenuator (VVA), providing RF output leveling. In this particular implementation, multiple parallel RF outputs are used to tune and calibrate a wide band receiver system. For other applications, the output switch and power divider array are replaced with a programmable RF amplitude modulator.



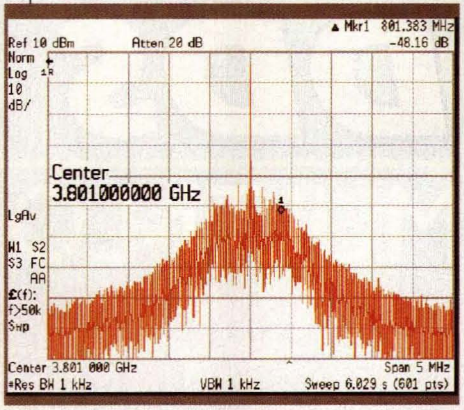
3. Frequency accuracy across the full tuning range is specified as 10 kHz.

Another Application

Another application for this synthesizer design is the replacement of digitally tuned oscillators (DTOs) in electronic-warfare (EW) systems and system simulators. A DTO consists of an oven-stabilized VCO with open-loop control. The open-loop control corrects the VCO input digital control data, using a memorized digital calibration. Unfortunately, DTOs are not without problems, including the power required for oven stabilization, post-tuning frequency drift, and the need for recalibration over time. The new synthesizer design does not employ oven stabilization, does not exhibit post-tuning output frequency drift, and does not require recalibration. With a total power requirement of 25 W, a volume of 20 in.^{3}, and the ability to quickly tune, in any frequency sequence, over the 2.25-to-18-GHz band, a single synthesizer may now replace multiple DTOs for significant cost savings and performance advantages. **Wide Band Systems, Inc., 389 Franklin Ave., P.O. Box 289, Rockaway, NJ 07866; (973) 586-6500, FAX: (973) 627-9190, e-mail: Marketing@widebandsystems.com, Internet: www.widebandsystems.com.**



4. This output spectrum was measured for a 2674.5-MHz carrier, with phase noise of –86 dBc/Hz 10 kHz away from the carrier and –96 dBc/Hz offset 1 MHz from the carrier.



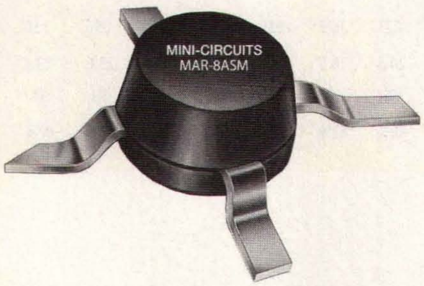
5. This output spectrum was measured for a 3801-MHz carrier, with phase noise of –76 dBc/Hz 10 kHz away from the carrier and –95 dBc/Hz offset 1 MHz from the carrier.

HBT Amplifier Gains From InGaP Technology

This versatile monolithic amplifier serves a variety of applications from DC to 1000 MHz using proven InGaP HBT device technology.

Linear amplifiers with high gain serve a multitude of uses in wireless communications and other applications. Gain is generally applied in a system to overcome signal losses from other receiver components, such as power dividers, antenna couplers, and filters. Often, several stages of amplification are needed to compensate for passive-component receiver losses, although the new model MAR-8ASM monolithic amplifier from Mini-Circuits (Brooklyn, NY) provides more than 30-dB small-signal gain from a single surface-mount package, enabling engineers to save a few stages and simplify their designs in the process.

ENGINEERING STAFF
Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235-0003; (718) 934-4500, FAX: (718) 332-4661, Internet: www.minicircuits.com.



1. The MAR-8ASM is a monolithic InGaP HBT amplifier supplied in a four-lead surface-mount package. It is usable to 1000 MHz with more than 31-dB gain at 100 MHz.

The MAR-8ASM **(Fig. 1)** is a monolithic microwave integrated circuit (MMIC) that incorporates reliable heterojunction-bipolar-transistor (HBT) devices fabricated with InGaP GaAs technology. InGaP transistors are formed on GaAs substrates with GaAs collectors and bases and InGaP emitters; material processing is performed by means of metal-organic chemical vapor deposition (MOCVD).

Compared to GaAs MESFET devices commonly used in wireless applications, HBTs are easier to design with and use. Because they are vertical devices, HBTs can be made very compact, with extremely high yields from a single wafer. HBTs require only a single positive voltage supply for operation, unlike GaAs MESFET devices which require both positive and negative voltage supplies. HBTs consume no power when they are turned off, eliminating the need for switch components used with other types of transistors.

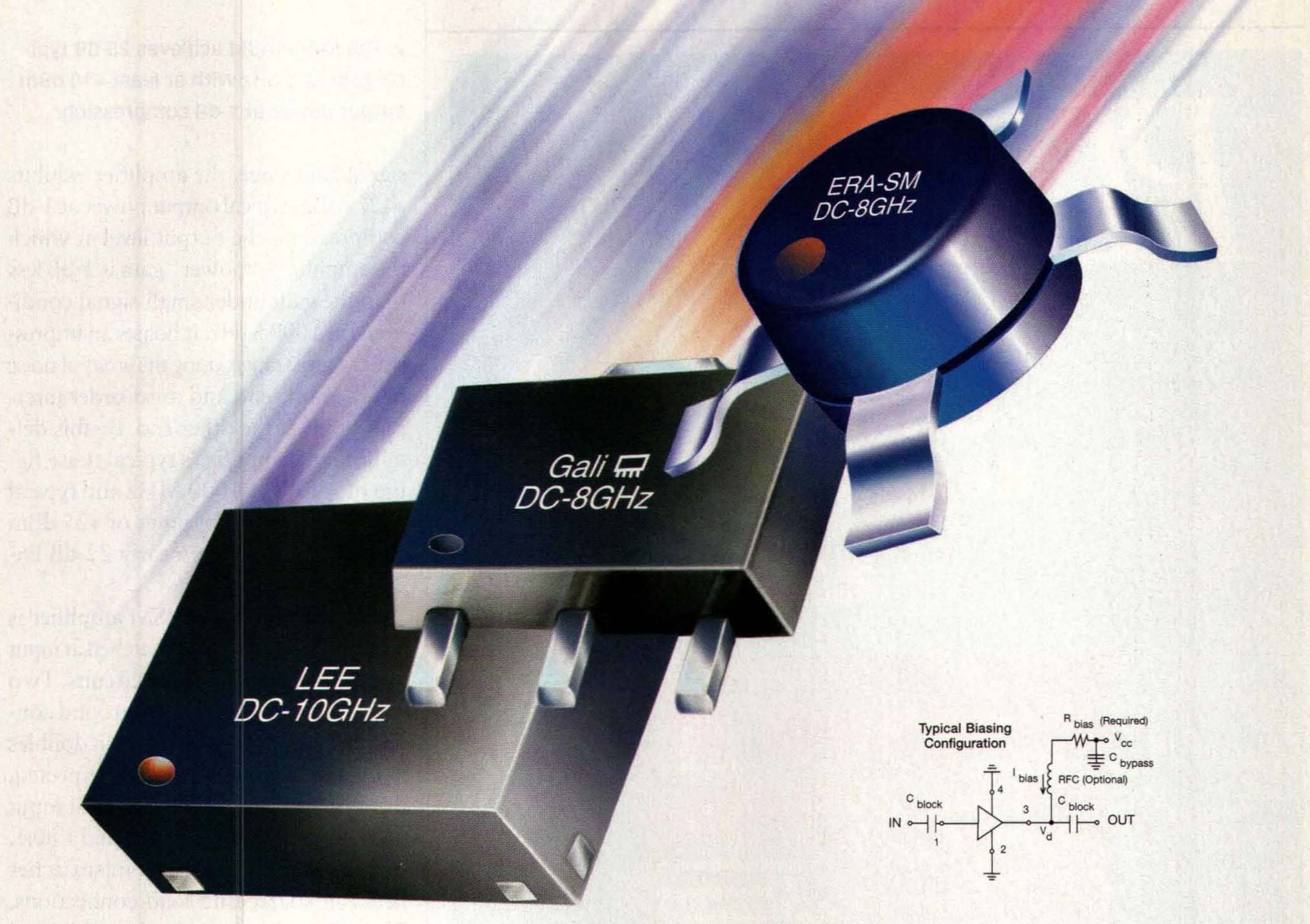
In recent years, controversy has developed over the use of AlGaAs emitters on GaAs for HBTs, which have been found to be unstable under certain conditions. InGaP materials exhibit lower initial defect densities compared to AlGaAs, resulting in higher yields per wafer and much longer operating lifetimes, on the order to 10 to 20 times longer. InGaP devices feature a much lower conduction-band offset between the InGaP in the emitter and the GaAs in the base, resulting in excellent uniformity of current gain with changes in applied current and operating temperature.

All of these factors account for the high power density, high efficiency, and superior linearity of InGaP HBTs compared to AlGaAs HBTs or even GaAs MESFETs at similar frequencies. By using thick interconnection metals in the InGaP HBT fabrication process, it is possible to produce devices that are small in size but exhibit excellent thermal properties. For example, the MAR-8ASM features thermal resistance of typically 140°C/W. With a maximum rated junction temperature of +150°C, the rugged amplifier can eas-

IN STOCK

MMIC AMPLIFIERS

DC-10GHz as low as 99¢ ea. (qty. 30)



GAIN FROM 8 up to 23dB, OUTPUT POWER up to +20dBm

If you need to find a MMIC amplifier with just the right performance and size to fit your design, your job just got easier! Introducing Mini-Circuits LEE, Gali, and ERA-SM families. Now you can select from a variety of over 40 broadband InGaP HBT and low noise silicon based models with flat gain from 8 up to 23dB, low to high output power of +2.8 to +20dBm, and very high IP3 up to 36dBm typical. These affordable, rugged, compact amplifiers have low thermal resistance for high reliability, and come in three different package styles to suit your design layout requirements; *the leadless 3x3mm "Mini-Circuits Low Profile" (MCLP™) package with exposed metal bottom for superior grounding and heat dissipation,* plus the SOT-89 and Plastic Micro-X with leads for easier assembly. You'll find all the performance specs and data on our web site, plus a wide selection of amplifier Designer's Kits with free test fixture included! So broaden your MMIC amplifier choices and maximize performance with Mini-Circuits LEE, Gali, and ERA-SM.

Detailed Performance Data & Specs Online at: ***www.minicircuits.com/amplifier.html***

Mini-Circuits...we're redefining what VALUE is all about!

Actual Size

Mini-Circuits®

P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661 For quick access to product information see MINI-CIRCUITS CATALOG & WEB SITE

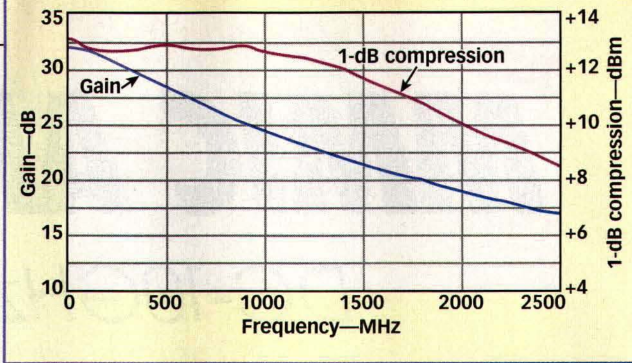
The Design Engineers Search Engine *Provides ACTUAL Data Instantly From MINI-CIRCUITS At:* ***www.minicircuits.com***

ISO 9001 ISO 14001 CERTIFIED

376 Rev. A

ily withstand input power levels to +13 dBm without damage or degradation of operating lifetime (more than 20 years).

The MAR-8ASM InGaP HBT amplifier is a versatile component, with usable bandwidth of DC to 1000 MHz and better than 20 dB gain across that full range **(Fig. 2)**. It achieves typical gain of 31.5 dB at 100 MHz, dropping to a still-impressive 25 dB typical gain at 1000 MHz. Although designed nominally as a small-signal gain stage, the amplifier exhibits +12.5-dBm typical output power at 1-dB compression (the output level at which the amplifier's "power" gain is 1-dB less than the gain under small-signal conditions) at 1000 MHz. It boasts an impressive dynamic range, using the limits of noise figure at one end and third-order intercept point at the other end. By this definition, the amplifier's typical noise figure of 3.1 dB at 1000 MHz and typical third-order intercept point of +25 dBm at 1000 MHz yield a nearly 22-dB linear dynamic range.



2. The MAR-8ASM achieves 25-dB typical gain at 1 GHz with at least +10 dBm output power at 1-dB compression.

The stable MAR-8ASM amplifier is a "ready-to-use" device, matched at input and output ports for 50-Ω circuits. Two of its four package pins are ground connections; the output connection doubles as the DC bias connection. As expected, the amplifier features low typical input and output VSWRs, of 1.40:1 and 1.80:1, respectively, to minimize mismatches between source and load connections. The MAR-8ASM requires few additional external components: a blocking capacitor on the input pin, a blocking capacitor on the output pin, a bias resistor on the RF output port, a bypass capacitor on the output port, and optional RF choke for the output port.

The amp is rated for operating temperatures from –40 to +85°C. It is designed for bias voltages of +3.2 to +4.2 VDC, and consumes 36 mA. It includes internal protection against power-supply transients, and is a form-fit replacement for the earlier MAR-8SM and MSA-0886 amplifiers. P&A: $1.19 each (30 qty.). **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235-0003; (718) 934-4500, FAX: (718) 332-4661, Internet: www.minicircuits.com.**

Cables Extend Test Range To 65 GHz

Combining excellent amplitude/phase stability with the trait of retaining shape once bent, these flexible cables are ideal for broadband microwave test applications.

JOHN LEWIS
Applications Engineer
MICRO-COAX, Inc., 206 Jones Blvd.,Pottstown, PA 19464-3465; (610) 495-0110,
Internet: www.micro-coax.com.

Test environments impose two conflicting requirements on microwave cables that run between the instrumentation and the device under test (DUT). Flexible cables must withstand repeated twisting, bending, and general mishandling while also delivering exceptionally stable amplitude and phase performance even with repeated flexing. To produce cables that can withstand this hostile environment, manufacturers of microwave test cables employ various design techniques and materials that make the cables forgiving over not only hundreds of thousands of flexures (and abuses). The ULTIMATE UTiFLEX family of microwave cables from MICRO-COAX (Pottstown, PA) support measurements from DC to 65 GHz, but without the fragility offer associated with millimeter-wave components.

With more than 15 years experience in manufacturing precision microwave cables, the designers at MICRO-COAX discovered that total flexibility is not necessary an ideal characteristic for a test cable. In order to use cables with excessive flexibility, test engineers have often resorted to supporting the cables in one or more locations between an analyzer and a DUT, resulting in complex test setups and expensive fixturing. To remedy this deficiency, MICRO-COAX gave the ULTIMATE UTiFLEX cables what it calls its Enhanced Test Bench feature, which results in a cable assembly that is flexible but self-supportive **(see figure)**. The cable can be set up once and will remain in position for the next test until repositioned. This reduces the amount of flexing the cables undergo, which in turn improves measurement repeatability and extends calibration intervals. Of equal importance, the Enhanced Test Bench Feature reduces the stress caused by the weight of test cables hanging

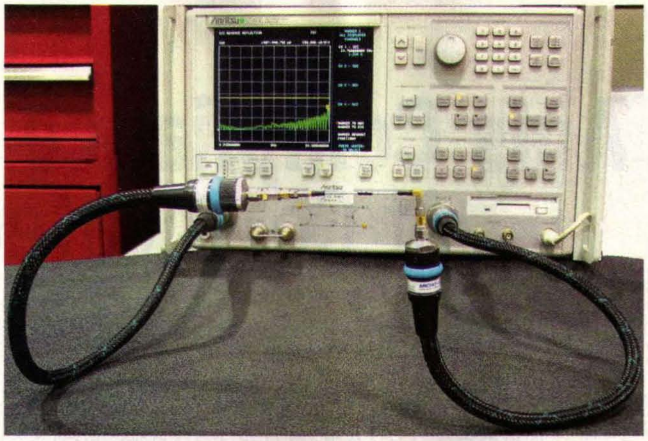
ULTIMATE UTiFLEX cables at a glance

Operating frequency range	
With V connectors	DC to 40 GHz
With K connectors	DC to 65 GHz
Phase[1] stability	+/-3 deg.
Amplitude stability[1]	+/-0.1 dB
Flex life	100,000 flexures
Minimum bend radius	1.5 in.
Tensile load	100 lb.
Crush resistance	1000 lb./linear in.
Available lengths	18, 24, 36 in.

1.24-in. assembly at 18 GHz

from a DUT.

ULTIMATE UTiFLEX cables are based on the company's standard flexible microporous test cable. This cable is enclosed in a proprietary flexible armor that provides a high degree of protection from kinking, denting, torquing, pulling, and crimping. The cables have crush resistance of 1000 lb./linear inch, good torsional resistance, and can withstand a static tensile load of 100 lb. The shielding effectiveness is typically better than 100 dB at 1 GHz while insertion loss is less than 1 dB/ft through 40 GHz.



ULTIMATE UTiFLEX cables are flexible but retain their position, eliminating the stress on the DUT caused by the cables and connectors, and reducing unnecessary flexing to extend recalibration intervals.

The center conductor, dielectric, and outer conductor (shield) of the cable are isolated within the assembly to ensure that the cable can be dropped, bent, and otherwise abused while maintaining the repeatability of all electrical parameters, the most important being amplitude and phase stability. The connectors used on ULTIMATE UTiFLEX are manufactured by the company specifically for this cable, and are optimized for VSWR performance and connector attachment to the armor. A ruggedized strain relief and anti-roll ring complete the package.

ULTIMATE UTiFLEX test cables, typically supplied in pairs, are available in 18-, 24-, and 36-in. lengths. Their mode-free frequency range is 40 GHz when equipped with 2.92-mm connectors and 65 GHz with 1.85-mm connectors **(see table)**. Each set of cables is tested for phase and amplitude stability, insertion loss, and return loss, and is supplied in a wooden storage case complete with test data and an owner's guide. **MICRO-COAX, Inc., 206 Jones Blvd., Pottstown, PA 19464-3465; (610) 495-0110, Internet: www.micro-coax.com.**

Meter Aids Compliance At Co-Located Sites

Co-located transmitter operators can now check their compliance with FCC regulations using a versatile selective radiation meter and broadband probes.

ROBERT JOHNSON
Manager, Instrument Products
Narda Safety Test Solutions, 45 Moreland Rd., Hauppauge, NY 11788; (631) 231-1700, FAX: (631) 231-1711, e-mail: nardast@l-3com.com, Internet: www.nardast@l-3com.com

Measuring the RF field strength of a single transmitter co-located with a host of similar transmitters/emitters is by no means simple. The daunting task has resisted the best efforts of system operators since 2000 when the FCC announced expanding safety rules for those working near RF transmitters. For accurate measurements, each transmitter must be measured individually while the others are turned off, much to the chagrin of silenced system operators. To solve this difficult problem, Narda Safety Test Solutions (Hauppauge, NY) has introduced the SRM-3000 selective radiation meter, a battery-powered instrument about the size of a paperback book that can measure the separate power levels of multiple signals without interrupting service. Within a few seconds, it measures all the emitters at a single site in three axes and displays the power levels in a list along with the percentage they contribute to the total field strength allowed by an applicable radiation protection standard such as ANSI/IEEE C95.1-1999 or FCC regulated limits.

The total field strength from all emitters is displayed as well.

The SRM-3000 (**see figure**) is a significant departure from the company's earlier radiation monitors. Earlier units are broadband instruments designed to show the total field strength of a co-located site over a range of frequencies, but cannot identify individual emitters at specific frequencies and calculate their strength as a percentage of the strength allowed by a standard. The lack of equipment that can perform these functions has made compliance with FCC guidelines very difficult because the only alternative is to either measure individual transmitters (at the expense of the remaining system operators) or to calculate the contribution of each signal manually.

Owing to the general laxity with which its rule change was received, the FCC has indicated that it will be far more vigilant in the future about ensuring compliance with the law. The FCC uses the "all transmitters off" method, guaranteed to get the message across loud and clear: Upon determining that there is a "hot" area near a given site, the agency simply informs the operators that they must at a specific time turn off all their transmitters at the site. The FCC then asks that they be turned back on one by one, while the field strength of each one is measured. Adding up the total provides the total EM field at the site. If it's greater than 100 percent of the applicable protection standard, all transmitters contributing more than 5 per-

The SRM-3000 selective radiation meter works with a triaxial or E-field probe to measure the power levels of emitters through 3 GHz.

cent of the total at the offending frequency must work to reduce the field strength or be fined or both.

In July 2002, FCC agents gave evidence of their vigilance at one of the most conspicuous transmitter sites in the US: the peak of Mt. Wilson north of Los Angeles, where most of Los Angeles County's FM and TV broadcasters transmit their signals. All transmitters were shut down, and then individually returned to service in a very short time after measurements were made, upsetting broadcasters and their customers. Had they been armed with the SRM-3000, the FCC could have performed their tests far less painfully.

The SRM-3000 essentially combines the measurement and analysis functions of a high-performance spectrum analyzer **(see table)** with the computational power of a Windows CE-based personal computer (PC). The primary probe employed by the SRM-3000 uses three, orthogonally mounted isotropic monopole antennas. The antennas are automatically switched at high speed, and the received signals are sent at their original frequency to the instrument via a special ferrite-shielded cable if the probe is mounted on a tripod or directly if the probe is attached to the instrument.

The signals then are processed by the spectrum analyzer that forms the foundation of the SRM-3000 (in addition to

(Continued on page 108)

The SRM-3000 at a glance

Frequency range	100 kHz to 3 GHz
Resolution bandwidths (in spectrum-analysis mode)	1 kHz to 5 MHz (depending on bandwidth)
Intrinsic noise	-110 dBm at 1-kHz RBW
Measurement time for one spectrum	<500 ms (100 kHz to 3 GHz, RBW 5 MHz)
Phase noise	>117 dBc/Hz at 1 MHz offset
IM-free dynamic range	>70 dB
RF immunity	500 V/m
Memory	200 spectra, 20 test set-ups
Input attenuator	0 to 50 dB in 10-dB steps
Probe type	Triaxial E-field (isotropic) or uniaxial E-field (dipole)
Probe sensitivity (900 MHz, 100 kHz RBW)	
Triaxial	5 mW/m
Uniaxial	10 mW/m
Measurement modes	Spectrum analysis, safety evaluation, time analysis
Detection	RMS with spectrum, max hold, average, and maximum average settings. Peak detection also in time-analysis mode
Comm port	RS-232
Display	Backlit monochrome, 480 x 320 pixel resolution, 4.7 x 3 in.

METER

(Continued from page 107)

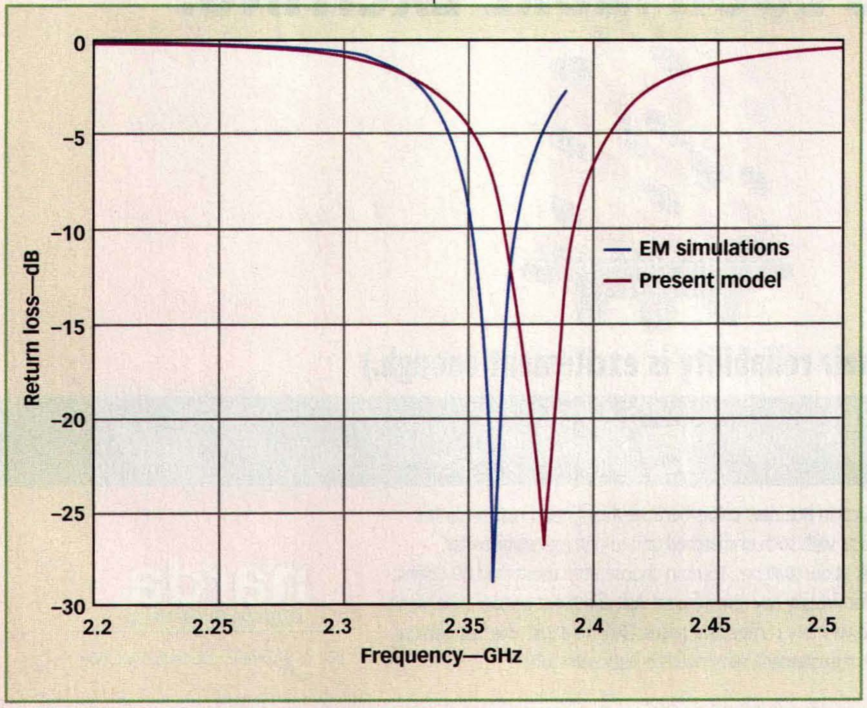
the probe technology). Algorithms in the Windows CE-based instrument calculate the required values, and the results are displayed on the 4.7 × 3-in (11.9 × 7.6-cm) 480 × 320-pixel monochrome display. The choice of monochrome was not made to reduce cost but because even the best color liquid-crystal-display (LCD) screens are not as viewable in direct sunlight as backlit monochrome types.

The SRM-3000 has three main operating modes: safety evaluation, spectrum analysis, and time analysis, and the results obtained from all three can be displayed in either tabular form or as a graphic, either one of which can be exported to popular programs such as Microsoft Word or Excel. The safety evaluation mode is the most interesting because here is where the tabular listing of signals appears by name (such as a call sign or service type), along with the field strength of each one as a percentage of a specific standard, and the percentage of the standard reached when signals at the site are combined. This mode allows the signals at a site to be sorted out by frequency, type of service, and measured field strength along with their relation to standard-imposed limits.

There are two other modes of operation: spectrum analysis and time analysis. In spectrum-analysis mode, the SRM-3000 displays the measured spectrum with resolution bandwidth and other parameters selected by the user. In the time-analysis mode, the user selects a center frequency and the resolution bandwidth corresponding to the bandwidth of the channel to be monitored. The display shows a current field strength value along with a plot of field strength over time. In every mode, the SRM-3000 can show field strength in V/m, A/m, W/m^2, or mW/cm^2.

The SRM-3000 measures 9.5 × 5.5 × 2.3 in. (24.13 ×13.9 × 5.8 cm) and weighs 4.2 lb. including rechargeable lithium-ion (LiIon) batteries. It will operate from 3 to 4 hr. on a charge, and can operate from 120 to 240 VAC via a supplied combination charger/converter. The instrument is heavily shielded, with RF immunity of 500 V/m.

The instrument has enough memory to store 20 user-defined test setups and 500 spectral plots, and can update its standards information via software and its RS-232C port. In addition to its 80-MHz-to-3-GHz triaxial probe, the company also offers a 30-MHz-to-3-GHz dipole E-field probe that can be mounted on a tripod for precision single-axis measurements. The instrument is supplied with a calibration report, RS-232 cable, configuration software, the charger/converter, and a battery pack. P&A: $15,000; stock. **Narda Safety Test Solutions, 435 Moreland Rd., Hauppauge, NY 11788; (631) 231-1700, FAX: (631) 231-1711, e-mail: nardasts@L-3com.com, Internet: www.narda-sts.com.**



5. This comparison of data from the transmission-line model and the EM simulation shows the accuracy of the model represented by Eq. 1.

(Continued from page 72)

close agreement is apparent between the return-loss profiles predicted by the two approaches. MRF

ACKNOWLEDGMENTS

The authors greatly appreciate the comments of Motorola iDEN group members.

REFERENCES

1. K.A. Carver and J.A. Mink, "Microstrip antenna technology," *IEEE Transactions on Antennas & Propagation*, Vol. 29, January 1981, pp. 2-24.

2. H. Pues and A. Van De Capelle, "Accurate transmission line model for the rectangular microstrip antenna," *IEEE Proceedings on Microwaves, Optics & Antennas*, Vol. 134, 1984, pp. 334-340.

3. David M. Pozar, "Input impedance and mutual coupling of rectangular microstrip antennas," *IEEE Transactions on Antennas & Propagation*, Vol. AP-30, November 1982, pp. 1191-1196.

4. Lorena I. Basilio, Michael A.Khayat, Jeffery Williams, and Stuart A. Long, "The Dependence of the Input Impedance on Feed Position of Probe and Microstrip Line – Fed patch Antennas," *IEEE Transactions on Antennas & Propagation*, Vol. 49, January 2001, pp. 45-47.

5. Daniel H. Schaubert, Frederick G. Farrar, Arthur Sindoris, and Scott T. Hayes, "Microstrip antennas with frequency agility and polarization diversity," *IEEE Transactions on Antennas & Propagation*, Vol. 29, January 1981, pp. 118-123.

(Continued from page 85)

tion results (Fig. 7) is 18.34 ns. Therefore, the resonator's unloaded Q by this calculation is $Q_u = (3.142 \times 1 \times 18.34)(2.544) = 57.62 \times 2.544 = 146.6$, which is the same result obtained in the calculation based on the bandwidth.

Figure 3 indicates that the resonator Q cannot be improved appreciably above the quarter-wavelength value unless a very low-loss capacitor is used. In the example above, the ESR of the capacitor was 0.025 Ω. If a single capacitor with that value of ESR is not practical, multiple capacitors can be placed in parallel with the resonator strip to obtain the necessary value. For example, four 1.3-pF capacitors all with ESR of 0.1 Ω combine in parallel to obtain the approximate 5-pF capacitance and 0.025 Ω ESR used in the example. Measurements taken in the lab with a commercial vector network analyzer verify the improvement in Q for a resonator constructed with multiple parallel capacitors.

A variety of oscillator performance parameters can benefit from a high-Q resonator, including phase noise and frequency drift (long-term frequency stability).

While shortening a resonator's length also improves its Q, the smaller size is also a desirable result. In this design example, a full-length (90-deg.) resonator would be 1.5 in. long at 1000 MHz, a length that may be impractical for a miniature voltage-controlled-oscillator (VCO) PCB. The shorter resonator, with length of only 0.5 in., is much more suited to the design of more compact, modern VCOs.

In summary, LINC2 is a high-performance RF and microwave circuit design and simulation program with many value-added features for automating design tasks, including circuit synthesis. This example showed how LINC2 can quickly and easily design high-quality-factor resonators to meet a given Q requirement and evaluate the suitability of different PCB material in meeting those objectives. More information about LINC2 and Applied Computational Sciences can be found on the website at www.appliedmicrowave.com. MRF

REFERENCES

1. T. Koryu Ishii, *Handbook of Microwave Technology*, Academic Press, New York, 1995, pp. 185-186.
2. D.B. Leeson, "A Simple Method of Feedback Oscillator Noise Spectrum," *Proceedings of the IEEE*, February 1966, pp. 329-330.
3. Peter Vizmuller, *RF Design Guide*, Artech House, Norwood, MA, 1995, p. 235.

Microwaves & RF 2003 Editorial Index

Microwaves & RF 2003 Editorial Index

COMPUTER-AIDED ENGINEERING

Microwaves & RF 2003 Editorial Index

Microwaves & RF 2003 Editorial Index

Attenuator Uses 5-b Binary Control

AMC MODEL ADVAN-218-15DD Options HS25NS and 5B is a 2-to-18-GHz digitally variable attenuator. The dynamic range is

15 dB in 0.5-dB steps and uses 5-b binary control. The switching speed is 15 ns maximum, 6 ns typical. The insertion loss is 3.0 dB at 2.0 GHz and 6.0 dB at 18.0 GHz. The VSWR is 2.0:1 maximum with 1.25:1 typically at 2.0 GHz and 1.53:1 typically at 18.0 GHz. The size is 2.0 × 1.9 × 0.45 in. (5.08 × 4.83 × 1.14 cm).

American Microwave Corp., 7311G Grove Rd., Frederick, MD 21704; (301) 662-4700, FAX: (301) 662-4938, e-mail: sales@americanmicrowavecorp.com, Internet: www.americanmicrowavecorp.com.

Synthesizer Is Designed For ATE Applications

THE IBS-18 BROADBAND SYNTHESIZER is designed specifically for ATE applications. The IBS-18 series synthesizers are based on indirect PLL design technology with internal DDS for fine resolution. The series is suitable for ATE as well as radar and EW system applications where broadband coverage, low phase noise, fast switching speeds, and reliability are of primary importance. The design architecture allows for switching speeds of 10 to 250 microseconds combined with very low phase-noise levels. The IBS-18 series can be customized to meet special applications such as EW threat and target simulators, surveillance, radar, antenna measurements, SIGINT, COMENT, ELINT, and flight-line ATE.

Elcom Technologies, Inc , 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030 ext. 230, FAX: (201) 767-6266, e-mail: sales@elcom-tech.com, Internet: www.elcom-tech.com.

Five-Port Switch Is Easy To Install And Operate

THE MODEL 5910 ETHERNET SWITCH is a five-port unmanaged switch used to route Ethernet messages in control and SCADA networks. The switch is easy to install and operate with no configuration necessary. The 5910 mounts on a DIN rail and is powered from the 5-V source available in all SCADAPack controllers and other 5000 series modules. The 5910 Ethernet gateway is also available with a desktop mounting option. Applications include inplant I/O and connectivity between SCADAPacks and operator workstations, other PLC devices and SCADA systems communications that use 10/100BaseT in an industrial environment.

Control Microsystems, 48 Steacie Dr., Kanata, Ontario K2K 2A9, Canada; (888) 267-2232, (613) 591-1943, FAX: (613) 591-1022, e-mail: salessupport@controlmicrosystems.com, Internet: www.controlmicrosystems.com.

Oscillator Spans Frequencies From 40 To 125 MHz

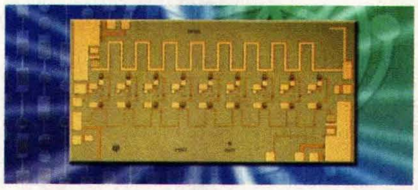
THE 235H SERIES IS a low-noise SC crystal oscillator offered in frequencies from 40 to 125 MHz with +13 dBm output

power into 50 Ω. Frequency stability is +0.05 PPM over an operating temperature range of 0°C to 70°C Phase noise is −124 dBc at 100-Hz offset with a noise floor of −172 dBc/Hz at 100 kHz on a unit with a 100-MHz center frequency. The 235H is housed in a 2.0 × 2.0 × 0.75-in. (5.08 × 5.08 × 1.9-cm) high steel can. Options include an AT cut crystal, RF output via PC pins or SMA-F connector, voltage-controlled or mechanical tuning, and dual RF outputs. Delivery is 12 wks. ARO.

Techtrol Cyclonetics, Inc., 815 Market St., New Cumberland, PA 17070; (717) 774-2746, FAX: (717) 774-6799.

Amplifier MMICs Offer Low Noise And High P1dB

A SERIES OF WIDEBAND MMIC low-noise, driver, and power-amplifier (PA) die products cover test equipment, military ECM/EW, fiber-optic, and microwave radio/VSAT applications from DC to 20 GHz. The family of four 50-Ω GaAs PHEMT distributed amplifiers offers gain levels of 14 to 17 dB, noise figure as low as 2 dB and P1dB output power levels ranging from +12 to +26 dBm. The



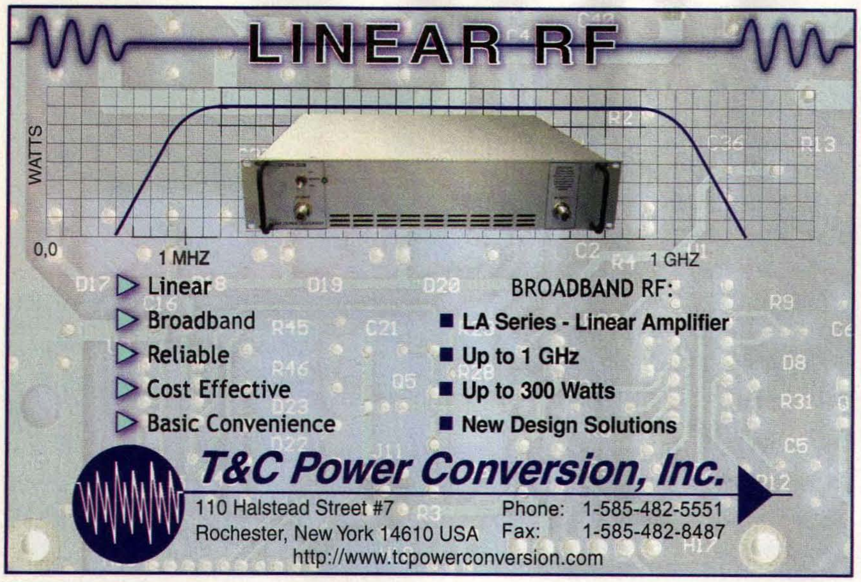
HMC462 is a self-biased low-noise amplifier (LNA) that offers gain of 15 dB ±0.5 dB and 2.5 dB typical noise figure (NF) from 2 to 20 GHz. The HMC462 delivers +14 dBm output power at 1-dB gain compression while requiring only 63 mA from a single +5-V supply. The HMC462 is the self-biased version of the HMC463.

Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01824; (978) 250-3343, FAX: (978) 250-3373, Internet: www.hittite.com.

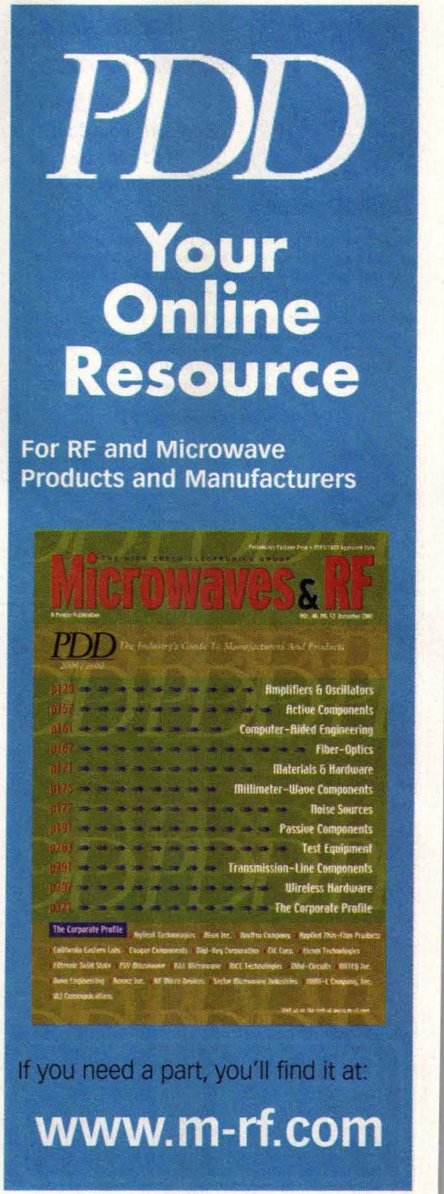
Front-End Receiver Features A Small Footprint

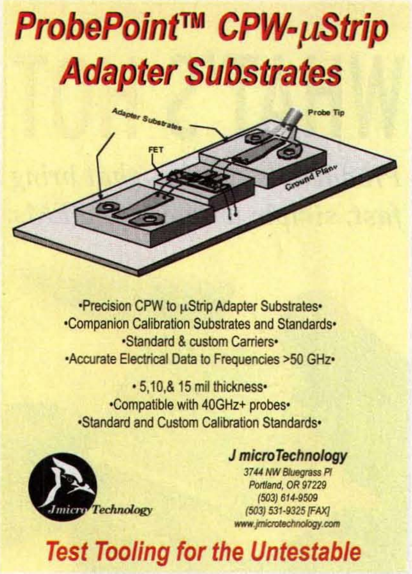
THE RF2861 SINGLE-BAND receiver front end with an integrated TX LO buffer amplifier is designed for CDMA, cellular, JCDMA, and CDMA450 applications. The RF2861 features a small (3 × 3-mm) footprint, which is designed to optimize board space and minimize cost for handset manufacturers. P&A: $1.88 (10,000 qty.); Samples, fully assembled evaluation boards, and production quantities are now available.

RF Micro Devices, 7628 Thorndike Rd., Greensboro, NC 27409-9421; (336) 664-1233, FAX: (336) 931-7454, Internet: www.rfmd.com.

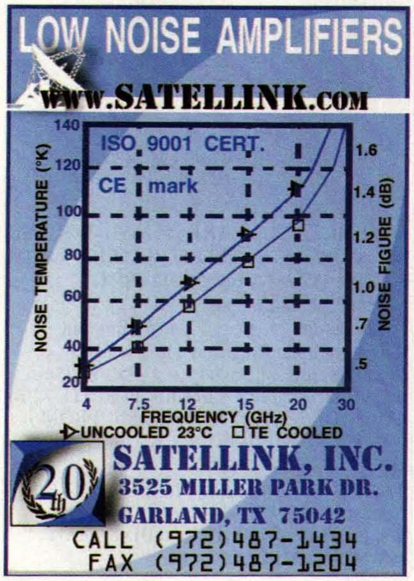


T&C POWER CONVERSION



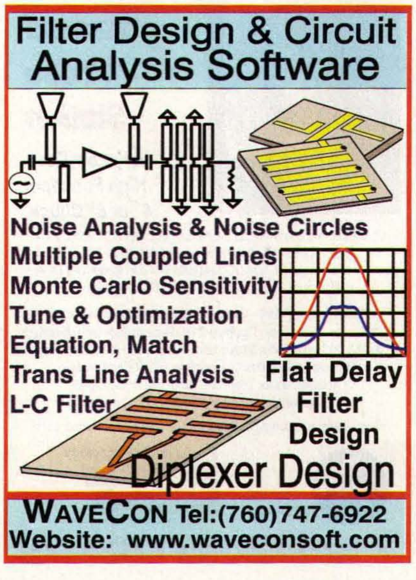


J MICROTECHNOLOGY

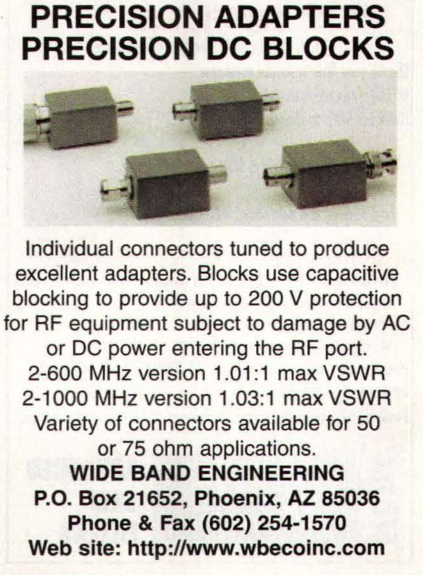


SATELLINK

UNIVERSAL MICROWAVE



WAVECON



WIDE BAND ENGINEERING

**Domestic Edition only **International Edition only This index is provided as an additional service by the publisher, who assumes no responsibility for errors or omissions.*

MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 845-2448
e-mail:croth@penton.com

SALES ASSISTANT
Judy Kollarik
(201) 845-2427
e-mail: jkollarik@penton.com

DIRECT CONNECTION ADS CLASSIFIED ADVERTISING
Joanne Reppas
(201) 666-6698
e-mail: jrepfrangides@msn.com

CIRCULATION CUSTOMER SERVICE (LIVE)
Phone: (847) 763-9670
Fax: (847) 763-9673
e-mail: microwaves&rf@halldata.com

NEW YORK, NEW ENGLAND, SOUTHEAST, MID ATLANTIC, DC, VA,
Paul Barkman
Global Sales Manager
Penton Media, Inc.
45 Eisenhower Dr., fifth floor
Paramus, NJ 07652
(908) 704-2460
FAX: (908) 704-2486
e-mail: pbarkman@penton.com

MIDWEST, SOUTHWEST, WESTCOAST, NORTHWEST, CANADA
Michael Barkman
Account Executive
Penton Media, Inc.
45 Eisenhower Dr., fifth floor
Paramus, NJ 07652
(908) 832-6551
FAX: (908) 832-7052
e-mail: mbarkman@penton.com

ITALY
Cesare Casiraghi
Viale Varese 39
22100 Como - Italy
Phone: 39-031-261407
FAX: 39-031-261380

GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
Germany
Phone: 011-49-202-271-690
FAX: 011-49-202-271-6920

SPAIN
Luis Andrade, Miguel Esteban
Espana
Publicidad Internacional
Sepulveda, 143-38
08011 Barcelona, Spain
Phone: 011-34-93-323-3031
FAX: 011-34-93-453-2977

FRANCE
Emmanual Archambeaud
Defense & Communication
48 Bd Jean-Jaures,
92110 Clichy
France
Phone: 33-01-47-30-7180
FAX: 33-01-47-30-0189

HOLLAND, BELGIUM
William J.M. Sanders, S.I.P.A.S.
Rechtestraat 58
1483 Be De Ryp, Holland
Phone: 31-299-671303
FAX: 31-299-671500

CZECH REPUBLIC
Robert Bilek
Production International
Slezska 61, 13000 Praha 3
Czech Republic
Phone: 011-42-2-730-346
FAX: 011-42-2-730-346

PORTUGAL
Paulo Andrade
Ilimitada-Publicidade
Internacional. LDA
Av. Eng. Duarte Pacheco
Empreedimento das
Amoreiras-Torre 2
Piso 11-Sala 11
1070 Lisboa, Portugal
Phone: 351-1-3883176
FAX: 351-1-3883283

TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co., Ltd.
11F/1, No. 421
Sung Shan Road
Taipei 110, Taiwan, R.O.C.
Phone: 886-2-2727-7799
FAX: 886-2-2728-3686

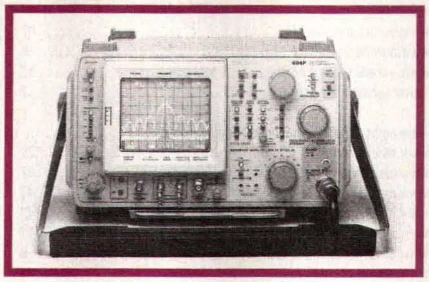
JAPAN
Hiro Morita
Japan Advertising
Communications, Inc.
Three Star Building
3-10-3 Kanda Jinbocho
Chiyoda-ku, Tokyo 101-0051, Japan
Phone: 81-3-3261-4591
FAX: 81-3-3261-6126

KOREA
Jo Young Sang
KPO Box 1916,
Rm 521, Midopa Bldg,
145 Dangju-dong, Jongro-ku
Seoul 110-722, Korea
Phone: 011-82-2-739-7840
FAX: 011-82-732-3662

INDIA
Shivaji Bhattacharjee
Information & Education Services
1st Floor, 30-B, Ber Sarai Village,
Near I.I.T. Hauz Khas, Behind
South Indian Temple
New Delhi, 110016 India
FAX: 001-91-11-6876615

Penton TECHNOLOGY MEDIA

looking back



THE JANUARY 1984 issue introduced the 494P, a groundbreaking portable spectrum analyzer from Tektronix (Beaverton, OR). Capable of surveying 10 kHz to 325 GHz with external mixers, the instrument packed laboratory precision into a field-worthy housing.

next month

Microwaves & RF January Editorial Preview

Issue Theme: Test & Measurement

News

January offers the middle installation of an exclusive trilogy of previews on the upcoming Wireless Systems Design Conference & Expo, moving to San Diego, CA for the first time next March. While the first installment highlighted the Keynote Address and panel sessions, this second report focuses on the technical sessions, with more than 60 technical presentations. These include full sessions on broadband wireless networks, 3G cellular technologies, handset design, design strategies for low-power applications such as RFID chips, power-management hardware and software, measurement techniques, wireless security issues and solutions, and WLAN design. In addition, January will also feature a special report on the recent ARMMS test and measurement meeting last November in Northamptonshire, England.

Design Features

January will explain useful techniques for measuring nonlinear distortion using a vector signal analyzer. Test strategies outlined by engineers from Rohde & Schwarz (Munich, Germany) will show how to quickly and precisely detect vector and scalar modulation errors as well as the distortion characteristics of complex communications signals. Additional design articles will examine polarimetric radar backscattering from power lines at microwave and millimeter-wave frequencies, for the purpose of detecting power lines along the paths of low-flying aircraft, and explore the performance of amplifying predistortion circuits that can be used to correct nonlinear distortion in high-frequency PAs.

Product Technology

January leads off 2004 by examining a line of frequency-selective impedance tuners capable of adjusting impedances at three different frequencies simultaneously. The patent-pending design is designed for high-power use and is ideal for tuning the amplitude and phase of on-wafer and discrete amplifiers and devices. As a look back at 2003, January will highlight the Top Products of 2003, as the editors of *Microwaves & RF* select their favorite product introductions from last year. In addition, Product Features will cover a line of frequency synthesizers with nanosecond switching speeds to 40 GHz, a line of spectrum analyzers that can trigger on selected frequency bands and capture broadband modulated signals, and a highly integrated circuit (IC) that supports both WLAN frequency bands and all three operating modes.

The Wait Is Over
MECA ELECTRONICS
INTRODUCES
e-meca.com
Attenuators, Couplers, Power Dividers and Termination
On-Line Convenience
Shipped The Next Business Day
Guaranteed
Dozens of standard items, in stock, ready to ship.
MECA
Premium microwave components since 1961
MECA Electronics, Inc.
459 East Main Street
Denville, NJ 07834-2515
Tel: (973) 625-0661 • Fax: (973) 625-1258
e-mail: sales@e-meca.com
VISA
MasterCard
AMERICAN EXPRESS Card
VeriSign Secure Site
Visa, MasterCard and American Express accepted.
Security assured by Verisign.